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Guiding Principles of the National Wildlife Refuge System

We are land stewards, guided by Aldo Leopold's teachings that land is a community of life and that love and respect for the land is an extension of ethics. We seek to reflect that land ethic in our stewardship and to instill it in others.

Wild lands and the perpetuation of diverse and abundant wildlife are essential to the quality of the American life.

We are public servants. We owe our employers, the American people, hard work, integrity, fairness, and a voice in the protection of their trust resources.

Management, training from preservation to active manipulation of habitats and populations, is necessary to achieve the missions of the National Wildlife Refuge System and the U.S. Fish and Wildlife Service.

Wildlife-dependent uses involving hunting, fishing, wildlife observation, wildlife photography, and environmental education and interpretation, when compatible, are legitimate and appropriate uses of the National Wildlife Refuge System.

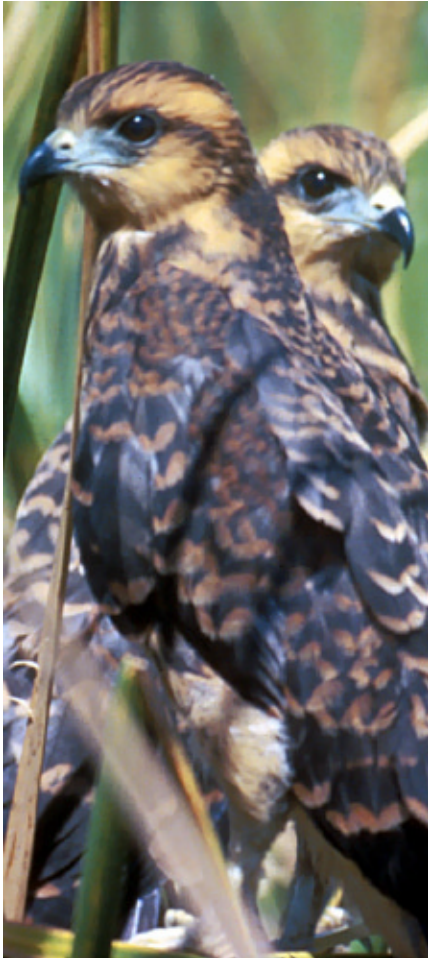
Partnerships with those who want to help us meet our mission are welcome and indeed essential.

Employees are our most valuable resource. They are respected and deserve an empowering, mentoring, and caring work environment.

We respect the rights, beliefs, and opinions of our neighbors.



I. Background



Immature Kites
Photo © Betty Wargo

Introduction

The U.S. Fish and Wildlife Service is developing a Draft Comprehensive Conservation Plan to guide refuge management and resource use at A.R.M. Loxahatchee National Wildlife Refuge in southeastern Florida. Contained in this draft plan is a description of the planning process, general background on the refuge, desired future conditions, refuge vision and goals, and the management actions necessary to achieve these conditions.

Guiding the development of the plan is Part 602 (National Wildlife Refuge System Planning) of the Fish and Wildlife Service Manual and the National Wildlife Refuge System Improvement Act of 1997. An overriding consideration reflected in the proposed plan is that fish and wildlife conservation has first priority in refuge management; public uses are allowed and encouraged as long as they are compatible with, or do not detract from, this priority mission and the purposes for which the refuge was established.

The major issues addressed in the plan include exotic species; biological diversity; water quality and quantity; land use changes; habitat and wildlife protection; recreational opportunities and access; and environmental education and partnerships. Based on these issues, a range of alternatives was identified that could be implemented within the next 15 years. From these alternatives, the Service has tentatively selected a preferred alternative, which is described in the following pages.

This plan supports the National Wetlands Priority Conservation Plan; the North American Waterfowl Management Plan; the Partners-in-Flight Initiative; the Multi-Species Recovery Plan for South Florida; the South Florida Ecosystem Plan, and the Comprehensive Everglades Restoration Plan.

Purpose of and Need for the Plan

The purpose of the plan is to identify the role the refuge will play in support of the mission of the National Wildlife Refuge System and to provide guidance in refuge management and public use activities. The plan articulates the Service's management direction (goals, objectives, and strategies) for the next 15 years (2000-2015).

The plan is needed to:

- provide a clear statement regarding the future management of the refuge;
- provide refuge neighbors, visitors, the public, and government officials with an understanding of the Service's management actions on and around the refuge;
- ensure that the refuge's management actions are consistent with the mandates of the National Wildlife Refuge System;
- provide long-term guidance and continuity for refuge management;
- provide a basis for the development of budget requests on the refuge's operational, maintenance, and capital improvement needs; and
- address the issues regarding the refuge's license agreement with the South Florida Water Management District, including issues relating to modification of the agreement and management capabilities and responsibilities.

Planning Process

A Draft Comprehensive Conservation Plan/Environmental Assessment was prepared in compliance with the National Wildlife Refuge System Improvement Act of 1997, and the National Environmental Policy Act of 1969. The Refuge System Improvement Act requires the Service to actively seek public involvement in environmental planning such as the preparation of environmental assessments and environmental impact statements. It also requires the Service to seriously consider all reasonable alternatives, including a “no action” alternative. These alternatives are described in the Environmental Assessment (*Appendix A*).

In developing the refuge plan, the Service completed a 3-step planning process, as follows:

- (1) Established and organized a planning team for the purpose of developing a refuge comprehensive conservation plan;
- (2) Held a public meeting to identify the important issues, concerns, and opportunities relating to the future management of the refuge; and
- (3) Prepared a draft plan for public review and comment.

On July 14-15, 1998, the Service assembled a planning team at the refuge headquarters to begin developing a draft plan for the refuge. The team developed a vision statement for the refuge and identified a number of issues and concerns that were likely to affect the management of the refuge. The planning team also identified several goals for the future direction of the refuge and planned the agenda for the first public scoping meeting.

The public scoping meeting was held in Boynton Beach, Florida, on August 17, 1998. This meeting identified a variety of issues, concerns, and opportunities concerning the management of the refuge. In addition, the Service distributed comment sheets and evaluated responses from persons who attended the public meeting as well as from those who could not attend the meeting. The comments from the public scoping meeting and those expressed on the comment sheets are summarized in Appendices G and I, respectively. These comments and each alternative and response are reflected in summary statements identified in Table 18.

Following the identification of the issues and opportunities, the planning team began the process of preparing the draft plan and environmental assessment. Information concerning the refuge’s physical, biological, and socioeconomic environment was compiled and is described in Section III, Refuge Environment.

At subsequent planning team meetings, the alternatives for the management of the refuge were identified. Each alternative was described as a set of objectives or management actions (*Appendix A*). The potential impacts of each alternative on the physical, biological, cultural and historic, and socioeconomic environments are also described in Appendix A.

The draft plan was distributed to officials of federal, state, and local government agencies, private organizations, and the general public for review and comment. A public meeting was held to present each alternative and obtain verbal comments from the public. In addition, a public meeting was held to present the draft plan. Comments were collected for a period of 40 days. Those comments were integrated into the preferred alternative (Ecosystem Emphasis).

The U.S. Fish and Wildlife Service

The U.S. Fish and Wildlife Service is the primary federal agency responsible for conserving, protecting, and enhancing the Nation's fish and wildlife populations and their habitats. Although the Service shares

this responsibility with other federal, state, tribal, local, and private entities, it has specific trustee responsibilities for migratory birds, threatened and endangered species, anadromous fish, and certain marine mammals, as well as for lands and waters administered by the Service for the management and protection of these resources.

As part of its mission, the Service operates more than 520 national wildlife refuges covering more than 92 million acres. These areas comprise the National Wildlife Refuge System, the world's largest collection of lands specifically managed for fish and wildlife. The majority of these lands, 77 million acres, is in Alaska, with the remaining 15 million acres spread across the other 49 states and several island territories.

The National Wildlife Refuge System

The mission of the National Wildlife Refuge System, as defined by the National Wildlife Refuge System Improvement Act of 1997, is:

"to administer a national network of lands and waters for the conservation, management, and where appropriate, restoration of the fish, wildlife and plant resources and their habitats within the United States for the benefit of present and future generations of Americans."

The Act establishes wildlife conservation as the primary mission of the National Wildlife Refuge System. Refuges will be managed to fulfill the mission of the National Wildlife Refuge System, fulfill the individual purpose of each refuge, and maintain the biological integrity, diversity, and environmental health of the system.

While wildlife will have first priority in refuge management, wildlife-dependent recreation uses or other uses may be allowed after they have been determined, by the Refuge Manager, to be appropriate

and compatible uses. Further, wildlife-dependent recreation uses, namely hunting, fishing, wildlife observation, wildlife photography, environmental education and interpretation are legitimate and priority public uses, are dependent upon healthy fish and wildlife populations and are to receive enhanced consideration over other public uses in planning and management.

National wildlife refuges provide important habitat for native plants, mammals, birds, fish, amphibians, reptiles, insects, and invertebrates. They also play a vital role in preserving threatened and endangered species. Refuges offer a wide variety of wildlife-dependent recreational opportunities, and many have visitor centers, wildlife trails, and environmental education programs. In 1995, 24.9 million people visited national wildlife refuges to hunt, fish, observe and photograph wildlife, and participate in educational and interpretive activities (U.S. Fish and Wildlife Service, 1997a). As visitation increases, significant economic benefits are generated to local communities. On a national basis, refuge visitors contribute more than \$400 million each year to local economies.



Tricolored Heron
USFWS Photo by Evelyn McGraw.

A.R.M. Loxahatchee National Wildlife Refuge

History

A.R.M. Loxahatchee National Wildlife Refuge, located 7 miles west of the city of Boynton Beach, is the only remnant of the northern Everglades in Palm Beach County, Florida (*Figure 1*). Unlike the name of many national wildlife refuges, Loxahatchee's name was changed in 1986 to include a noted local conservationist Arthur R. Marshall. Most of the 147,392-acre refuge is encompassed by Water Conservation Area 1, which is owned by the State of Florida and is licensed to the Service.



White ibis colony
USFWS Photo by F. Broerman

To the northwest of the refuge is the Everglades Agricultural Area which includes sugar cane farms, winter vegetable and sod farms, and cattle ranches. The land east of the refuge is predominantly urban with the exception of the agricultural lands of the East Coast Buffer area. To the south and southwest of the refuge lie Water Conservation Areas 2 and 3, and Everglades National Park--the only other remaining portions of the Everglades fresh water marsh.

Beginning with the Swampland Act of 1845, and later the 1907 Everglades Drainage Act, excessive drainage activities occurred in the Everglades to pave the way for agriculture and development. To meet the ever-increasing water needs of agriculture and population expansion, three water storage areas called Water Conservation Areas 1, 2, and 3 (*Figure 1*), were constructed by the U.S. Army Corps of Engineers in the 1940s. Bounded by levees and connected by a series of canals, these areas were placed under the jurisdiction of what is now the South Florida Water Management District, an agency of the State of Florida.

In 1951, a license agreement (*Appendix N*) between the South Florida Water Management District and the Service, under the Migratory Bird Conservation Act, enabled the establishment of the 143,238-acre Loxahatchee National Wildlife Refuge at Water Conservation Area 1. This "refuge interior" land, as it is called, is owned by the State of Florida, but managed by the Service. The license agreement was later amended to include the 1604-acre Strazzulla Marsh, which lies adjacent to Water Conservation Area 1 (*Figure 2*).

In addition to the lands licensed from the District, the Fish and Wildlife Service owns 2,550 acres to the east and west of the refuge interior. This acreage is sub-divided into four management compartments--A, B, C, D, and the Cypress Swamp. In total, the refuge currently includes 147,392 acres of northern Everglades habitat.

The refuge is currently managed by a staff of 20 permanent and 4 temporary/seasonal personnel. The permanent personnel include a project leader, deputy project leader, a refuge operation specialist, 2 Everglades Program Team members, 2 administrative staff, 3 law enforcement staff, 4 biological staff, 4 maintenance/operations staff, and 2 public use staff. In fiscal year 1999, the refuge operated with a budget of \$1,451,000 for payroll and operation needs and received \$357,000 in special funding authorized by Congress to address the maintenance backlog. For fiscal year 2000, the refuge was allocated \$1,520,700 for payroll and operation needs and also received \$144,100 for projects authorized by Congress.

The refuge Headquarters Area is the main entrance for refuge administration, education, and public access. It contains an entrance fee booth, administration building, a visitor center, four permanent residences, the Everglades Program Team office building, a vehicle storage building, four sheds, and a maintenance complex. In addition to these administrative facilities, the area contains three boat ramps, a floating boat house, seven parking lots, a boardwalk, an observation tower, observation platform, and a fishing platform. The Hillsboro Recreation Area, located at the southernmost point on the refuge, contains a parking area and boat ramps.

Figure 1. Regional perspective for A.R.M. Loxahatchee National Wildlife Refuge

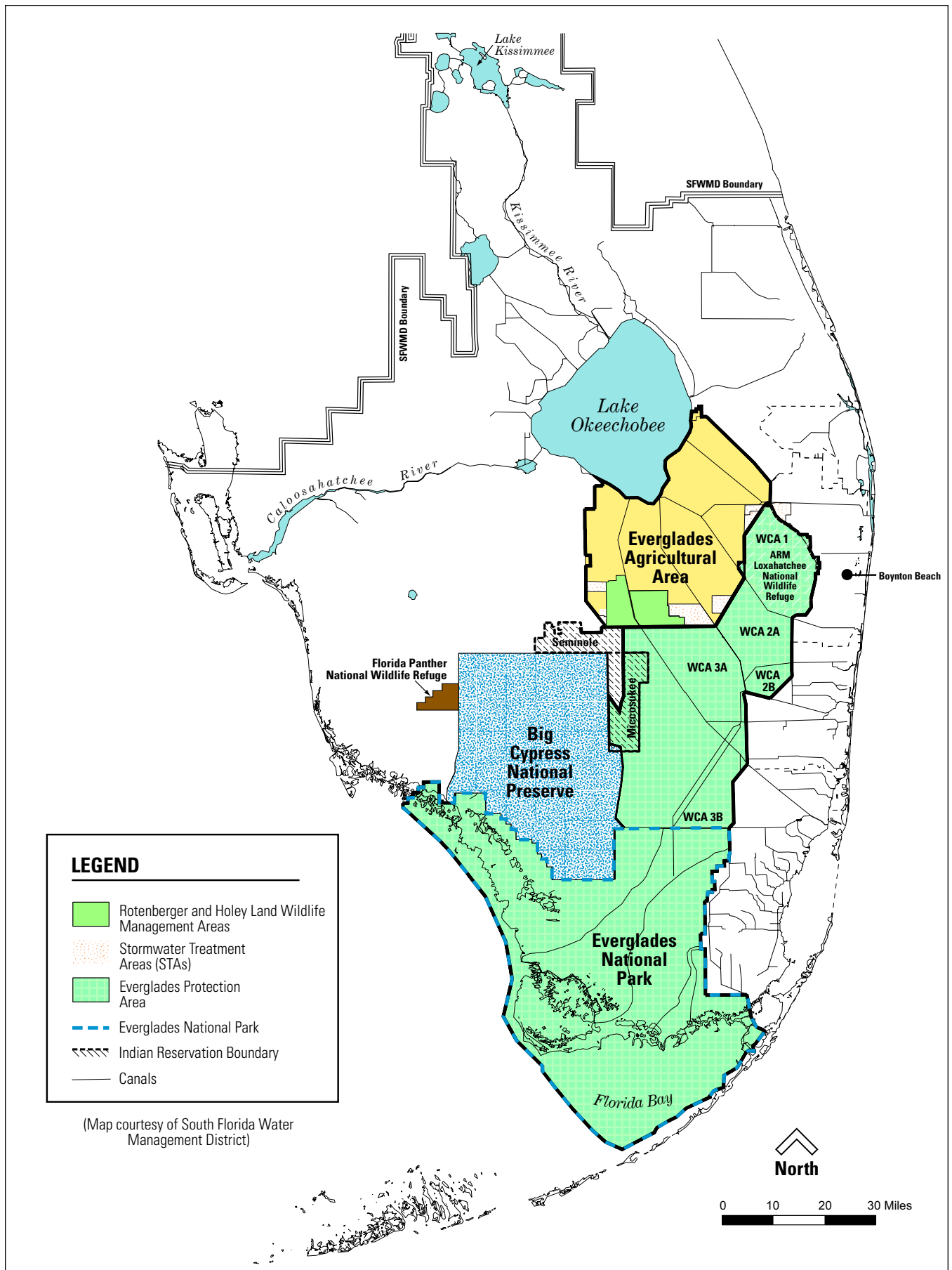
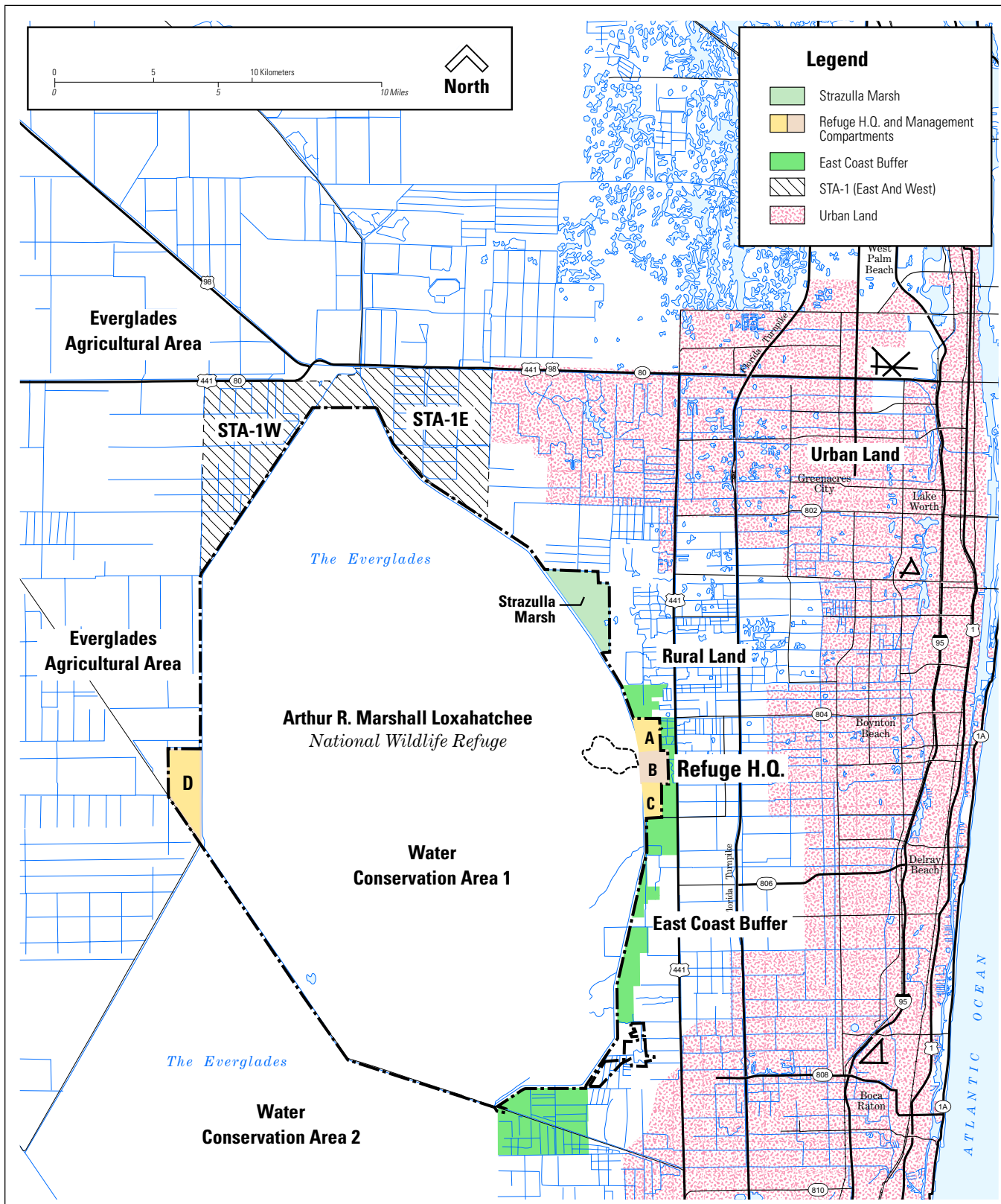


Figure 2. Boundaries and potential buffer lands at A.R.M. Loxahatchee National Wildlife Refuge



Purpose

The Migratory Bird Conservation Act of February 18, 1929, 45 Stat. 1222, the Act of June 30, 1948, 62 Stat. 1171, 1176, authorizing the construction of the Central and Southern Florida Flood Control Project and the Fish and Wildlife Coordination Act of March 10, 1934, 48 Stat. 401, amended by the Act of August 14, 1946, 60 Stat. 1080, authorized the establishment of Loxahatchee National Wildlife Refuge on January 1, 1951.

The refuge was created by two agreements entered into by the Department of the Interior. The first agreement is a General Plan with the Florida Game and Fresh Water Fish Commission (now the Florida Fish and Wildlife Conservation Commission) which permitted Water Conservation Area 1 to be used by the Fish and Wildlife Service for the national migratory bird management program. The second agreement is a long term License from the Central and Southern Florida Flood Control District (now the South Florida Water Management District) which provided for the use of Water Conservation Area 1 by the Service “as a Wildlife Management Area, to promote the conservation of wildlife, fish, and game, and for other purposes embodying the principles and objective of planned multiple land use.”

According to the Fish and Wildlife Coordination Act, this refuge

“...shall be administered by him (Secretary of the Interior) directly or in accordance with cooperative agreements... and in accordance with such rules and regulations for the conservation, maintenance, and management of wildlife, resources thereof, and its habitat thereon....” (16 USC § 664).

The Migratory Bird Conservation Act of 1929 states that the refuge is to be “...for use as an inviolate sanctuary, or for any other management purpose, for migratory birds.” (16 USC. § 715d). This purpose and the mission of the National Wildlife Refuge System is fundamental to determining the compatibility of proposed uses of the refuge. The compatibility of these uses is discussed in Appendix D.

Ecosystem and North American Context

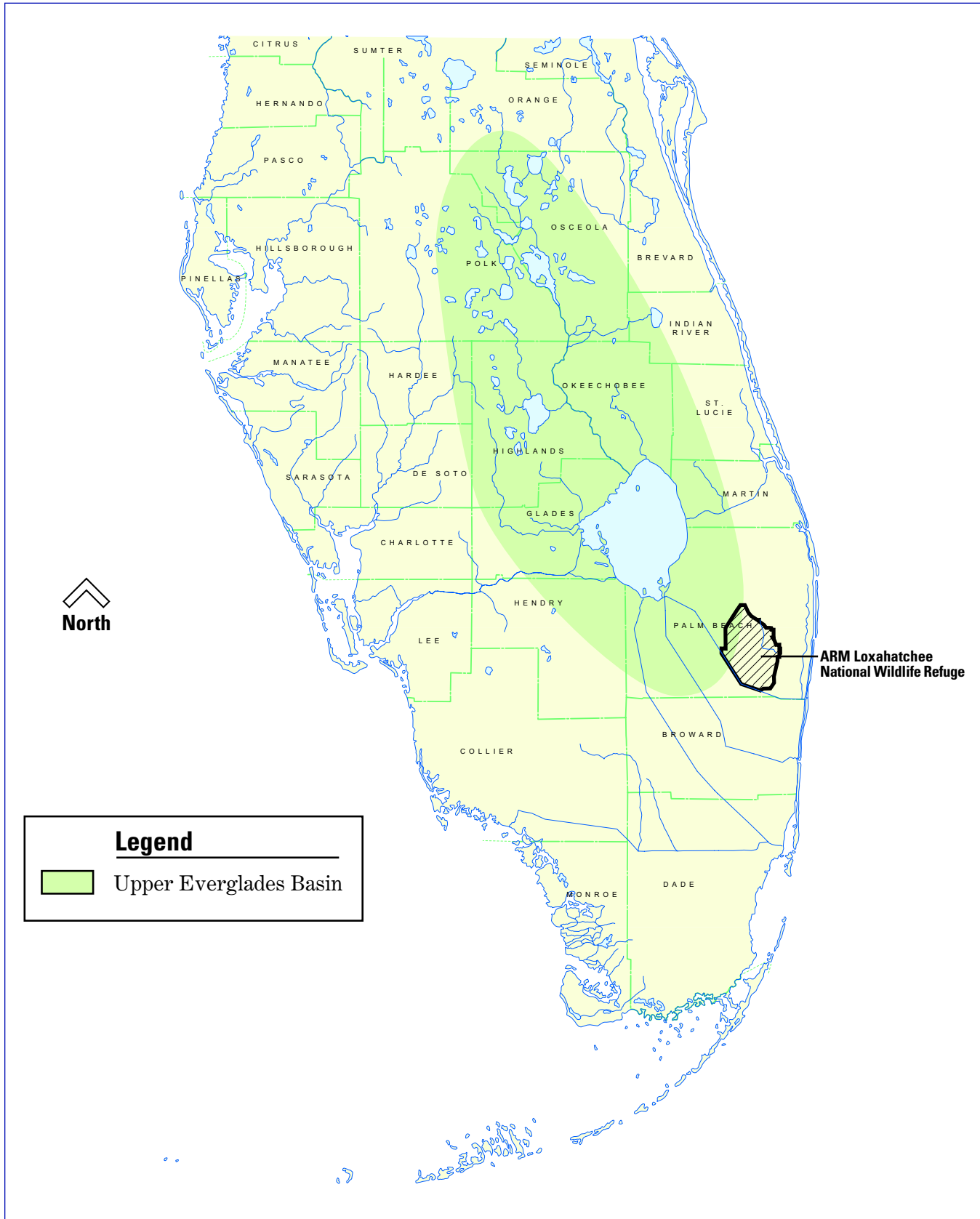
Role of Refuge in South Florida Ecosystem Plan:

In response to the complexity of the South Florida and Everglades Ecosystems, a South Florida Ecosystem Plan was completed by the Service’s South Florida Ecosystem Team. This plan identified the goals, objectives, and strategies for this ecosystem and the major issues associated with eight ecosystem sub-regions. The refuge, located in the Florida Everglades ecosystem subregion (*Figure 3*), will make a significant contribution to achieving the objectives of this plan. Consistent with the South Florida Ecosystem Plan, the refuge will reduce exotic species; manage water quality and quantity through partnerships; inventory and monitor wildlife and habitat; enforce laws to protect refuge resources; promote public awareness about the ecosystem; provide wildlife-compatible recreation; and maintain facilities and equipment at or above Service standards.

The Refuge Manager attends and participates in monthly working group meetings of the South Florida Ecosystem Team, which is comprised of Service field stations in an area from Ft. Myers to Vero Beach and south to the Keys. This team works together to accomplish Service priorities which include protection and management of federal trust species and combating the ever increasing problem of exotic invasives.

During the past two years the refuge has taken an active role in partnership efforts to protect and enhance habitats and wildlife both on and off refuge. Staff members have participated on water preserve area study teams designed to provide buffer lands east of the Everglades that will provide short hydro-period wetlands, enable ground water recharge, and capture water for storage and delivery to east coast populations. Staff

Figure 3. Upper Everglades Basin of importance to central Florida wintering waterfowl, breeding mottled ducks and wood ducks



are also working closely with county and state efforts to provide wildlife corridors and greenways connecting several of the large land management areas. In addition, the refuge is an active participant in Palm-Net, a network of federal, state, and county agencies and private organizations working together to provide interpretation and environmental education opportunities to the public.

Role of Refuge in Everglades Restoration:

The refuge is an important part of the overall Everglades ecosystem. The refuge receives water flowing south from Lake Okeechobee (S5-A Pump Station) and the Everglades Agricultural Area (S6 Pump Station). Discussions of re-plumbing the Everglades have included decompartmentalization including removal of the levees surrounding the refuge. However, removing the western and southern levees would allow water to flow south to Water Conservation Areas 2,3 and Everglades National Park, but would result in less control over maintaining water in the northern part of the system. In addition, because of land subsidence north and west of the refuge, if the levees were removed, water would flow north and west instead of the historic southerly direction and drain the refuge. Model runs of decompartmentalization show a decrease in Lake Okeechobee levels and a decrease in overall water supply leading to the conclusion that at this time, removal of the levees would not be beneficial to water supply or ecological values of the system or to the refuge. However, as part of the restoration, agricultural drainage water that comes through the S6 Pump Station would soon stop and it will be re-routed through the new Stormwater Treatment Area 2, and into Water Conservation Area 2.

The construction of canals throughout the Everglades ecosystem, as a whole, has changed historic sheet-flow patterns. Comparisons of newly shot aerial photos to historical aerial photos show elongate tree islands appear to be losing their overall appearance of a teardrop or a strand shape. Studies indicate that loss of a consistent north to south water flow over the refuge is one of the factors contributing to this landscape change (Brandt 2000).

The refuge's water regulation schedule, revised May 1995, has provided a mechanism to keep water levels in the refuge from dropping below 14 ft. NGVD. This schedule keeps the refuge from completely drying out every year. Though periodic dry outs are part of the natural cycle, yearly dry outs can reduce fish populations (prey for many species including wading birds), reduce the number of apple snails available for snail kites, provide additional areas for the germination and spread of exotic vegetation, and increase fire risks. Since the adoption of the regulation schedule in 1995, no major fires have occurred in the refuge, and the refuge experienced a record year for wading bird nesting in 1999. Stormwater Treatment Areas 1 East and 1 West will assist hydropatterns by providing a ready reservoir of low nutrient water that the refuge can draw from when needed.

Water quality and water quantity issues will continue to be major concerns in the protection of the resource. Until there are assurances that water entering the refuge is clean, options that put more (greater than recent levels) dirty water into the refuge are not considered ecologically beneficial. The existing water regulation schedules appear to be benefitting the ecological system within the refuge. Protecting the resources in the refuge contributes to overall Everglades restoration in that it helps to maintain the spatial extent and heterogeneity of historic habitats. This will contribute to the overall maintenance of system biological diversity.

The refuge is working cooperatively with the Corps of Engineers and South Florida Water Management District to better manage water resources in the context of multiple uses (needs for the environment, urban, and agricultural uses), including the use of long term forecasting and rainfall driven operations. Refuge personnel have, in the past and more recently,



Mottled Ducks
USFWS Photo by B. Thomas, Jr

increased participation in discussions of restudy and restoration alternatives by participating in various committees and advisory groups including:

- Alternative Evaluation Team coordinated by the Corps of Engineers (disbanded 1999)
- Restoration Coordination and Verification and subteams (i.e., Adaptive Assessment Team, Regional Evaluation Team) coordinated by the Corps of Engineers
- Water Preserve Area
- Technical Oversight Committee
- Everglades Technical Advisory Committee

Partners-In-Flight Program:

Recent documentation of plummeting bird numbers, especially of migrant passerines (Hagen and Johnston 1989, Finch and Stengel 1992) stimulated the formation of Partners-In-Flight, an international organization to address the needs of non-game migratory birds. The Service is one member of the Partners-In-Flight Program that includes coordination between federal, state and non-governmental agencies, industry, and conservation groups to promote research, land protection, and education about migratory birds.

The refuge is in the Atlantic Flyway, one of the primary migratory routes of bird species that breed in temperate North America and winter in the tropics of the Caribbean and South America. More than 116 species of neotropical migrants have been recorded passing through the south Florida ecosystem. More than 129 bird species migrate to the south Florida ecosystem to overwinter, and another 132 species breed in the ecosystem. Because this ecosystem is located near Cuba and the West Indies, it draws Caribbean species that rarely appear elsewhere in North America.

In 1995, the Service prepared a list of migratory non-game birds of management concern in the United States to stimulate a coordinated effort by federal, state, and private agencies to develop and implement comprehensive and integrated approaches for the management of selected species (*Tables 22 and 29*). The south Florida ecosystem supports many of these species (*Appendix L*).

Western Hemisphere Shorebird Reserve Network:

The refuge is also an important stopover location for many species of migratory shorebirds and a nesting location for some shorebirds. Although the refuge is not designated as a strategic migrational site by the Western Hemisphere Shorebird Reserve Network, it does provide important foraging habitat for these species and contributes survey data to the network.

North American Waterfowl Management Plan:

Since the first settlers arrived, more than 50 percent of the United States' original 220 million acres of wetlands, upon which waterfowl depend, have been destroyed often causing dramatic declines in numerous waterfowl populations.

Although some populations have declined, waterfowl remain an economically important group of migratory birds on the North American continent. According to the 1996 National Survey of Fishing, Hunting and Wildlife Associated Recreation, approximately 1.8 million people spent \$740 million annually to hunt ducks, both on and off national wildlife refuges. About 18.6 million people spent \$2 billion observing, photographing, and otherwise appreciating waterfowl throughout the United States, not just on refuges (Fish and Wildlife Service, Division of Federal Aid).

Recognizing the importance of waterfowl and wetlands to North America and the need for international cooperation to promote their well-being, the Canadian and United States governments developed a strategy to restore

waterfowl populations to the levels of the 1970s through habitat protection, restoration and enhancement. The strategy was documented in the North American Waterfowl Management Plan, which was signed in 1986 by the Canadian Minister of the Environment and the United States' Secretary of the Interior. This plan identified important waterfowl habitat areas, established habitat and population goals, and established interstate/international partnerships, called joint ventures, to implement plan goals.

In 1997, the Atlantic Coast Joint Venture continued to build upon its firm foundation as Florida became its 17th state partner. Mid-winter data indicate that 17 to 26 percent of the Atlantic Flyway's January censused duck population winter in north and central Florida--an incidence greater than in any other state in the flyway.

A small portion of the refuge lies within the Upper Everglades Basin, which provides winter waterfowl habitat for scaup, ring-necked ducks, redheads, blue- and green-winged teal, wigeon and fulvous-whistling ducks, which are the most abundant species of waterfowl wintering in all of Florida (*Figure 4*). It also provides breeding habitat for mottled and wood ducks. Thus, the refuge has the potential of providing habitat for a portion of the North American wintering population, especially for ring-necked ducks. Management activities contribute towards meeting numerous goals of the North American Waterfowl Management Plan.

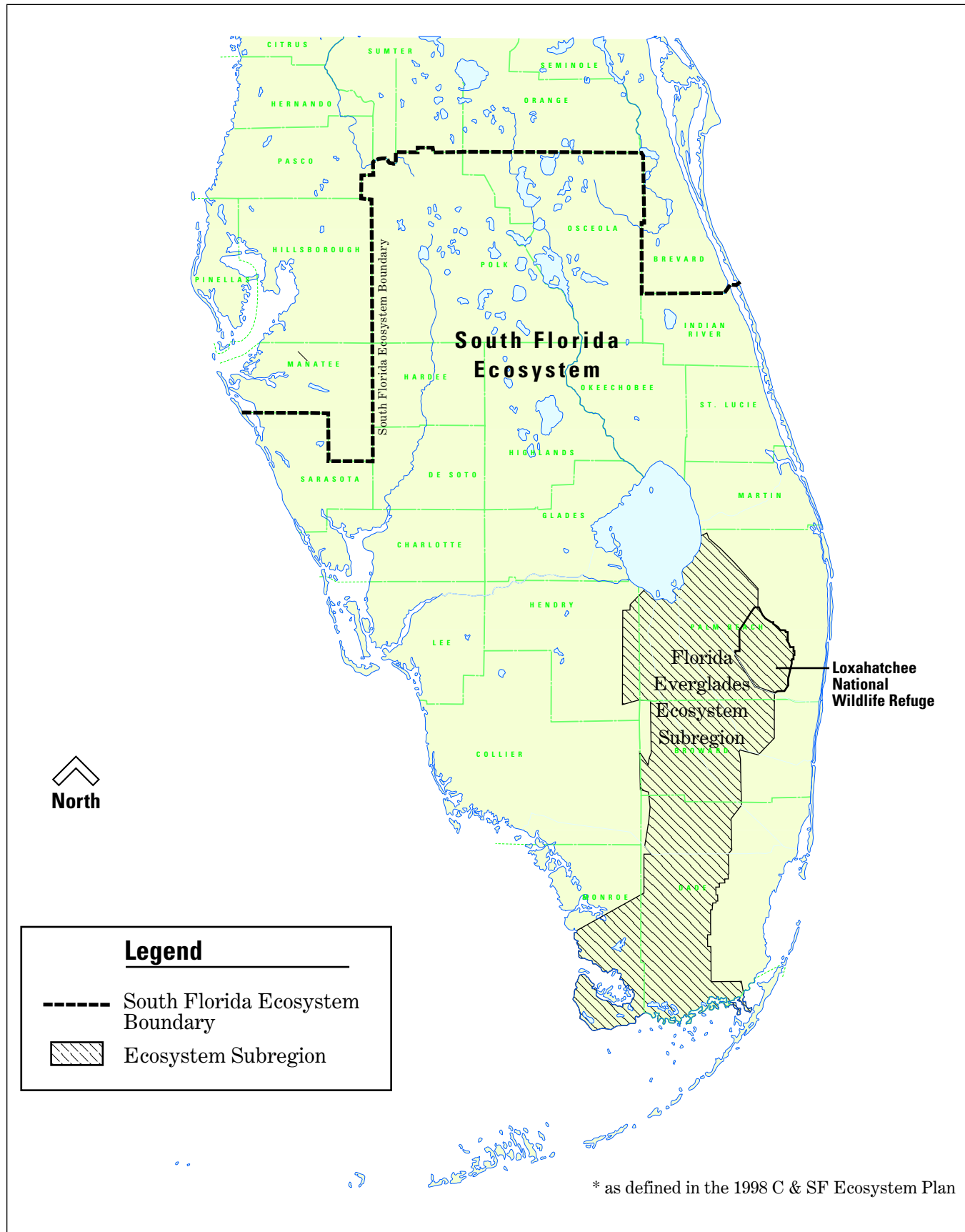
The issue of high mercury levels found in resident fish and alligator body burdens raises concerns about resident waterfowl. Population monitoring and heavy metal testing is needed for mottled and wood ducks including determining if a health advisory is needed regarding these locally harvested species. It is assumed that because they are not fish-eating birds the levels are within tolerance levels, however testing would be prudent.

Legal Context

In addition to the refuge's authorizing legislation and the National Wildlife Refuge System Improvement Act of 1997, the legal and policy guidance for the operation of national wildlife refuges is contained in the documents or acts listed below. For a description of the key legislation and policies, see Appendix F.

- Executive Order 1312- Invasive Species (2/3/99)
- National Wildlife Refuge System Administration Act of 1966 (16 USC 668dd-668ee)
- Refuge Recreation Act of 1962 (16 USC 460k-460k-4)
- Title 50 of the Code of Federal Regulations, Subchapters B and C
- The Refuge Manual
- Fish and Wildlife Service Manual
- Endangered Species Act of 1973 (16 USC 1531-1543)
- Migratory Bird Hunting and Conservation Stamp Act (16 USC 718-718h)
- Migratory Bird Treaty Act of 1918 (16 USC 703-712)
- National Environmental Policy Act of 1969 (PL 91-190, 42 USC 4321-4347)
- Bald Eagle Protection Act of 1940 (16 USC 668-668d)
- American Indian Religious Freedom Act (P.L. 95-341, [1978], 92 Stat. 42 USC 1996)
- Antiquities Act (P.L. 59-209, approved 6/8/1906, 34 Stat. 225, 16 USC 431-433)
- Archaeological Resources Protection Act (P.L. 96-95 [10/31/1979], as amended by P.L. 100-555 [10/18/1988] and P.L. 100-588 [11/3/1988], 93 Stat. 721, 16 USC 470 aa et seq.)
- Archaeological and Historic Preservation Act (P.L. 93-291 [1974, 88 Stat. 1974], amending Reservoir Salvage Act, 16 USC 469)
- Executive Order 13007 - Sacred Sites (5/24/1996)
- National Historic Preservation Act (P.L. 89-665 [1966], 80 Stat. 95, as amended by P.L. 96-515 [1980], 94 Stat. 2987; P.O. 102-575 Title 40 (1992), 106 Stat. 4600)
- Native American Grave Protection and Repatriation Act (P.L. 101-601 (1990), 104 Stat. 3048, 25 USC 3000-3013, 18 USC 1170)

Figure 4. Florida Everglades Ecosystem Subregion* within the South Florida Ecosystem



II. Planning Issues and Opportunities



Boat-tailed grackle
USFWS Photo by Evelyn McGraw

Introduction

Early in the development of this plan, the planning team developed a list of issues and concerns that was likely to be associated with the management of the refuge. This list was derived from team knowledge of the area, a public scoping meeting, and written comments submitted by the public.

The scoping meeting, held on August 17, 1998, provided the public with an opportunity to identify issues and concerns. Approximately 60 persons attended the meeting. After a 15-minute presentation on the values of the refuge, the meeting participants were divided into small groups, with the group discussions facilitated by a consultant and planning team members. The comments of each group, following a structured format, were recorded on flip charts. These comments are summarized in Appendix G. Responses from comment sheets, distributed at the scoping meeting and at the refuge, and handwritten letters or postcards also provided information on issues and concerns of importance to the public. The comment packet and a summary of the comments are found in Appendix H and I, respectively.

Using the above sources, the planning team developed an abbreviated list of statements reflecting major issues and concerns. While the summary statements, presented below, may not be identical to the original statements given by the public, the statements accurately reflect the intended meaning of the comments received. The responsiveness of the alternatives to these issues and concerns is summarized in Appendix A, Table 18.

Summary Statements

Wildlife Habitat Management

- The increasing number of exotic and invasive plant and animal species is negatively impacting the refuge's native wildlife and habitat.

Many local citizens were concerned about the threat exotic plants and animals pose to the ecosystem and to the water supply. The public mentioned such threats as melaleuca, Old World climbing fern, Brazilian pepper, Australian pine, walking catfish, armored catfish, the bromeliad weevil, and the Asian fresh-water marsh eel. It is their desire that the refuge staff increase its efforts to protect native plants and wildlife from these threats.

- There is a need to improve the management of species and habitats to enhance the native biodiversity and integrity of the refuge.

Many citizens stated that it is imperative that the refuge manage the remaining portion of the Everglades to improve habitats and wildlife populations. Some people believe that past refuge administration allowed wildlife and habitats to decline and they wish that the land had been better managed. Many people expressed frustration at the poor condition of the impoundments and wondered why there was not more wildlife available to observe on a year-round basis.

- The degraded water quality and past water management practices (e.g., water quantities and schedules) are negatively impacting the refuge's ecosystem.

Many people stated the need for better water quality and an adequate water quantity for the refuge. Other people, however, expressed concern about having sufficient water for agriculture and the urban areas, particularly if the refuge takes what it needs.

Refuge Protection

- The refuge is threatened by rapid development of residences, planned communities, strip malls, or golf courses near its boundaries.

Many people recognize the threat of impending development and its impact on the natural land base in the south Florida region, and they wish to protect lands around the refuge from development. Some people would like to see the current agricultural land use adjoining the refuge perpetuated or more land set aside for natural areas. Many people appeared to understand the fragility of the Everglades ecosystem and support restoring adjacent lands to a native state.

- The wildlife and habitats are not protected enough.

Many comments were written supporting greater protection of refuge wildlife and habitats, especially for threatened and endangered species. Many people expressed a desire to see the whole biological system protected. Others believe that providing protection to wildlife and habitat is especially important even if it means limiting public access.

Public Use

- There are not enough opportunities to observe wildlife and its habitat in a quiet, natural, non-developed environment.

Many people expressed their appreciation for the refuge, its relatively quiet environment and its undeveloped nature. Since much of the land in south Florida has been developed (in their view), the refuge needs to stay relatively unsullied and quiet--a sanctuary for the public as well as for wildlife. Some people wished that more areas of the refuge (e.g., Strazzulla Marsh or the perimeter levee) were open so they could participate in more passive wildlife observation. Many people said that they don't want any activity that will disrupt wildlife populations or damage wildlife habitat.

- There is a need for increased access to the refuge for active recreational uses such as hiking, camping, bicycling, horseback riding, canoeing and airboating.

A number of people would like to bicycle, horseback ride, ride all-terrain vehicles, camp, hike, or airboat on the refuge. Many people believe that many kinds of recreation have not been offered to the public and should be. Due to the loss of natural lands in south Florida, people said they want to be able to enjoy green space in ways other than walking.

- There is a need to provide increased access to the refuge for hunting waterfowl, deer, alligator, turkey, bear and frogs. The habitat needs better management for fishing and hunting activities.

- Some people expressed frustration that the refuge provides a limited amount of access for hunting; further, they wished that the refuge allowed the use of airboats, especially for that purpose. Others desired a greater number of species to hunt. A number of individuals expressed frustration with what they perceive to be poor management of hunting and fishing habitat, especially with regard to the dense cattail growth at the south end of the refuge.

- Don't allow airboating.

A number of people wrote comments and stated at the public meeting that the refuge should not be opened to private airboating.

- There is a need to provide access and improve/provide public use facilities at the Hillsboro Recreation Area and at Strazzulla Marsh.

Many people expressed a desire for improved facilities and support services at the Hillsboro area, located at the south end of the refuge. The desired facilities and services should include a concession (with interpretive tours, boat rentals, educational experiences), usable boat ramps, telephones and restrooms. In addition, some people wished to have access to Strazzulla Marsh. Many people were concerned about the poor maintenance of the canoe trail and lack of additional access to the refuge interior. A few people desired an access point at the north end of the refuge to replace the closed “20-Mile Bend” access point.

- There is a need to expand environmental education and interpretation, highlighting the Everglades ecosystem.

Many people want to experience a greater number and variety of environmental education programs on the refuge. Further, they want their children to learn about the Everglades through the refuge. Some people said that new exhibits are needed, which can be rotated, and that facilities needed to be upgraded. Some citizens wished that the refuge would provide more educational tours for school and senior citizen groups, and summer camps.

Partnerships

- There is a need for the refuge to develop partnerships with state, county and community agencies, universities and educational institutions, natural resource based organizations and other entities.

People think the refuge should work more closely with other natural resource agencies and user groups. To enhance management, some people believe there is a need to share equipment and knowledge between agencies.

- Take the refuge from the Fish and Wildlife Service and give it back to the State (Florida Fish and Wildlife Conservation Commission).

Some people do not want the Service to manage Water Conservation Area 1. Currently, a license agreement with the South Florida Water Management District gives authority to the Service to manage wildlife in keeping with its mission and establishing legislation, but the Water Management District retains the authority to manage water for flood control and water supply. These citizens feel the Agreement has been violated regarding wildlife and habitat management and by public access.

- Many of the public wish the refuge to develop ecotourism connections with the business community.

Citizens recognize that the refuge is a tourist attraction and they hope that it can continue to be beneficial to the local economy. Some citizens wish the refuge would join the Chamber of Commerce and create connections between hotels, recreational sport organizations and businesses.

Significant Resource Problems

Water quality, quantity and timing, invasive and exotic plants and animals, and urban growth are three major factors affecting the welfare of fish, wildlife, and plants on the refuge and the surrounding ecosystem.

The defining element of the refuge and the whole of the Everglades is water, its quality, delivery timing and amount. This unique ecosystem has had a very low nutrient base for thousands of years and is comprised of species that have evolved to thrive under low nutrient conditions. Human activities adjacent to the refuge have introduced nutrients, primarily



Melaleuca
USFWS photo by M.D. Mattei

fertilizers, which enhance the growth of many non-indigenous and invasive species to the detriment of native species. Increased nutrients change bacteria and algae, the most basic level of the system. This moves through the system until it is visible as the vast unnatural acreages of cattail. Replacing the natural Everglades marsh vegetation, these nuisance species create monotypic stands that are far less productive for wildlife and lacks the visual appeal of a diverse natural Everglades.

The reduction of nutrients entering the refuge has been and will continue to be a major issue. The Everglades Nutrient Removal Project was completed in October 1993 (South Florida Water Management District 1997). This

serves three primary purposes: (1) to reduce phosphorus loads entering the refuge and help minimize imbalances in Everglades flora and fauna; (2) to develop the design, construction, operations, and maintenance experience necessary for large scale application of flow-way treatment technology; and (3) to implement optimal nutrient removal technology.

Currently the Everglades Nutrient Removal Project is in the last stages of conversion to Stormwater Treatment Area 1-W. Stormwater Treatment Area 1-E, through which surficial water will also be filtered, will be built adjacent to the northeast portion of the refuge. The Everglades Nutrient Removal Project, combined with best management farming practices, has already achieved phosphorous levels below the original goal of 50 PPB. However, a numeric standard still needs to be set for the amount of phosphorus that no longer causes an imbalance to flora and fauna. To reach this standard will require design and implementation of new technology. The standard will not only provide a basis for assessing the financial resources required to achieve water quality, but also a basis for monitoring.

Because the Everglades is no longer a free-flowing system that relies on temporal weather patterns to sustain it, humans must now attempt to provide water when and where the system can most benefit. The system evolved under variation, not constant annual schedules. Unfortunately, the water delivery system in place often exhibits its inadequacies in the form of extended droughts or floods. Technology must be developed and implemented to allow water managers to be more responsive to the natural system's needs and still meet the demands for water supply and flood control.

Exotic plants and animals are a tremendous threat to the ecosystem and to its water supply. The refuge has the worst invasive exotic plant problem in all of south Florida, and among the worst in National Wildlife Refuge System, with more than 96,000 acres infested to varying degrees. The amount of funding needed to control exotic plants is great, especially considering the insufficient funding nationwide for national wildlife refuges. A greater awareness is needed to maintain the refuge's biological integrity (See Refuge Environment, Exotic Plants).

Species such as melaleuca, Old World climbing fern, Brazilian pepper, Australian pine, walking catfish, and now the South American armored catfish, bromeliad weevil, and Asian fresh-water marsh eel are threats that are currently visible. New "exotics" will undoubtedly appear as the refuge struggles to find controls for established species. Exotics are not just costly threats to the natural environment, but also to agriculture, land development, business, and human health as well.

To meet the demands of a growing urban population, there is a continuous stream of land use proposals for lands surrounding the refuge. These proposed land use changes are often detrimental to the natural environment and the aesthetics of the area. For example, power transmission lines and high speed rail have been proposed to extend through the refuge natural and public use areas. Solid waste disposal sites have been proposed to abut the refuge boundary, which will bring unsightly mountains of waste adjacent to public use areas and adversely affect wildlife and water quality. However, the most likely immediate threat is from the rapidly escalating speed with which strip malls and housing developments are being built, especially adjacent to the refuge borders.

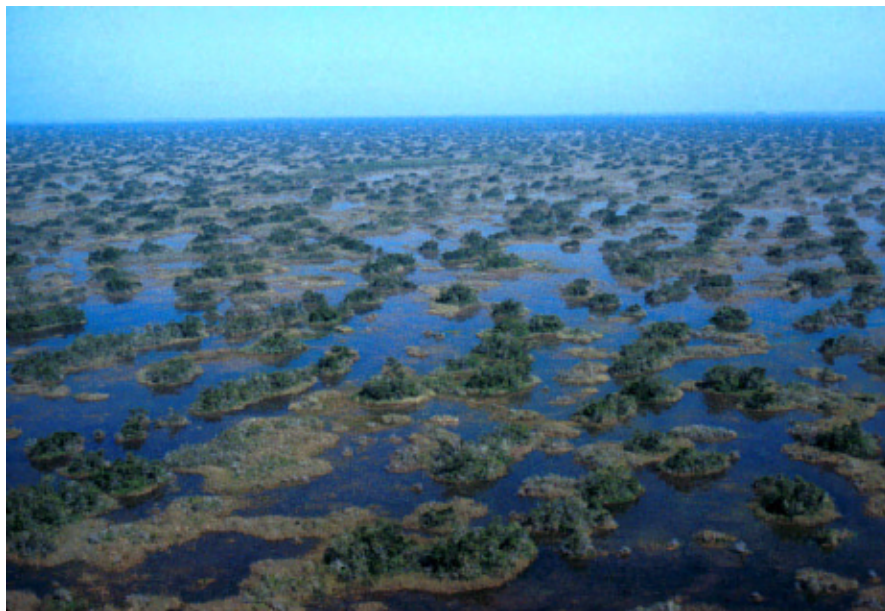
III. Refuge Environment

Physical Environment

Climate

Located in the subtropical region of south Florida, the refuge's climate is hot and humid most of the year and the winters are mild. In general, there are two seasons--wet and dry. The wet season occurs from late May to late October. The refuge receives some of the highest amounts of rainfall in south Florida (Gleason et al., 1975). While annual rainfall ranges from 40 to 83 inches, about 60 inches is typical. More than one-half of the rainfall for the year occurs between June and September in the form of thunderstorms. Only one hurricane (Irene in 1999) has made a direct hit on the refuge since it was established, however, numerous hurricanes

and tropical storms have skirted it, and these have caused large rainfall events primarily during the months of August to November. During the dry season, November to May, rain falls during the cold fronts which average about seven per month from December through March, but the amount is significantly less than during the wet season.



USFWS Photo by S.D. Jewell

Winds prevail out of the southeast and the average relative humidity is 75 percent. While air temperatures at the refuge have ranged from 20°F to 101°F, the mean summer temperature and the mean winter temperature are 89°F and 56°F, respectively. The combination of humidity and temperature causes heat indices to range from 105°-110°F in the summer. Since the eastern edge of the refuge is located

within 12 miles of the Atlantic Ocean, temperatures are moderated. The temperatures also are moderated by the surface water of the Everglades.

Physiography, Soils, and Geology

The refuge is composed of 147,392 acres of Everglades habitat. The refuge is part of a large fresh water storage area connected by a series of canals and levees, which were completed by the Corps of Engineers in 1960. The underlying aquifer provides water into nearby coastal communities.

Underlying the refuge is a depression in the Fort Thompson Formation, a limestone bedrock, which results in greater water depth than the surrounding Everglades. Unlike other areas of the Everglades, where there are only shallow layers of soil overlying the bedrock, soil depths in the refuge range from 3.6 - 14.0 feet (Silveira 1996). The soil is primarily Loxahatchee Peat which forms from the roots, rootlets, and rhizomes of white water lily, and is an indication of a historic slough community. The peat is lightly colored, fibrous and spongy, reflective of high organic content. The low ash content of the soil is an indication of infrequent burns in the area.

Loxahatchee Peat is found only in two areas in the Everglades--in the refuge and Water Conservation Area 2, and in the western portions of Water Conservation Area 3 and Shark Slough. Loxahatchee Peat is slightly more acidic and has lower mineral content than other peats. The oldest peat on the refuge has been dated at 4,800 years. Everglades Peat (formed primarily from sawgrass) and Gandy Peat (formed from woody material, especially associated with tree islands) also are present on the refuge.

The refuge is on a gradual north to south slope which results in slowly moving surface water sheet flow. The topography undulates throughout the refuge, creating mounds and depressions that are covered by varying depths of water. In addition, the refuge contains thousands of tree islands which form when a layer of peat dislodges itself from the substrate and floats to the surface. During periods of low water, tree islands become rooted to the substrate. Plant succession occurs rapidly, and within about three years, woody vegetation is established.

Hydroperiod and Hydropattern

Water flowing from the Everglades is vital to supplying surface water for south Florida, replenishing the Florida and Biscayne aquifers, carrying essential nutrients and clean, fresh water to estuaries, and supporting an extremely rich and diverse assemblage of wildlife and plants. Changes in the hydroperiods (the duration that an area is inundated) and hydropatterns (the depth, timing, flow, and location of surface water) have altered these vital wetland functions in the south Florida ecosystem.

Historically, surface water originating from rainfall and natural springs flowed from the Kissimmee basin of central Florida. The spring fed creeks formed rivers and filled Lake Okeechobee. From that point, water overflowed the south end of the lake and began its southward sheet flow to the southern tip of Florida. Historically, the precipitation that fell on the Everglades could spread out over the entire area (>2,317 square miles). To prevent flooding and provide agricultural and developmental land use, the Corps of Engineers started the massive and historic effort of controlling Everglades waters through construction of hundreds of miles of levees and canals. This construction has not only constricted sheet flow, but also has removed excess Everglades water to the ocean. As the levees and canals were completed, water ceased its natural flow through the Everglades; rather, it was channeled through what is now the refuge. In contrast to the past, water now enters the refuge from rainfall and three access points of controlled surface flow.

Construction of the levees has had significant effects on the hydrology, vegetation, and wildlife in the refuge. The shallow shorter hydroperiod marshes that once surrounded the refuge have been replaced by deep-water habitats along the canals. Lost is the mosaic of habitats that provided, in the same year, the availability of deeper water slough habitats for foraging snail kites and shallower marshes for foraging wading birds (e.g., wood storks). Changes in the natural timing of water levels affect wading bird feeding patterns, apple snail reproductive output, and alligator nesting. In addition, changes in the patterns of water depth have resulted in changes in aquatic vegetation and tree islands. In areas that have become wetter, particularly along the rim canal, tree islands have decreased in size and number (Brandt 2000), and more aquatic communities have developed (Hagenbuck et al., 1974). In drier areas, particularly the northern portion of the refuge, woody vegetation has become more abundant (Hagenbuck et al., 1974). Lower water levels, particularly during the dry season, increase the potential for fire and for fires to burn hotter, resulting in more damage to vegetation and soils.

Another consequence of impoundment has been the reduction of water flow through the refuge. A reduction in flow rates has changed the patterns of nutrient transport, seed dispersal, soil accretion, or loss. Brandt(2000) provided some evidence that changes in flow as well as hydroperiods and depths have contributed to the changes in the patterns of tree islands in the refuge. The importance of flow as a structuring process, as well as hydroperiods, should be considered for the maintenance of the ecological integrity of the refuge and the Everglades.

Timing and volume of water releases from the refuge also have influenced lands and waterways east and south of the refuge. By sending water to the eastern urban areas, water flowing southward through the Everglades ecosystem is greatly reduced, resulting in increased salinity in Florida and Biscayne Bays. Prior to June, in preparation for the hurricane season, the Corps of Engineers releases a large volume of fresh water from the refuge into the Atlantic Ocean. This heavy pulse of fresh water into the nearby Atlantic Ocean dilutes the saline environment, creating negative affects on fish and marine life. Because this water is released near the refuge, the water cannot complete its historical sheet flow to the tip of south Florida. The loss of fresh water to Florida Bay has created hyper-saline conditions, which have negatively impacted the estuarine and bay production and the entire fishing industry.

Overview of Water Regulation

Purpose:

A.R.M. Loxahatchee National Wildlife Refuge, also known as Water Conservation Area 1, is part of the Corps of Engineers' Central and Southern Florida Project for Flood Control and other purposes (*Figure 5*). Water levels in Water Conservation Area 1 are regulated by a schedule to produce optimum benefits among competing interests. These interests are flood control, water supply (agricultural, municipal, and industrial), fish and wildlife enhancement, prevention of saltwater intrusion, and water supply to Water Conservation Areas 2 and 3 and Everglades National Park. To produce these benefits, the water level (elevation) in the refuge is adjusted as the year progresses, either by a release of water from Water Conservation Area 1, an intake of water from Lake Okeechobee, or by a combination of water release and intake.

Water Intake:

The current major sources of water for the refuge are rainfall (56 percent), the S-5A, G-251, G-310, and S-6 pump stations (40 percent), and ACME 1 and 2 pump stations (4 percent). These stations are located at the north, west and east sides of the refuge (*Figure 6*). The S-5A station pumps water from the West Palm Beach Canal; the G-251 and G-310 stations pump water from the Stormwater Treatment Area 1-W; the S-6 station currently pumps water to the Hillsboro Canal, but will soon be diverting all of this water into STA-2; and the ACME 1 and 2 pump stations discharge water from Basin B in the Village of Wellington area. The amount of water that comes in from S-6 is approximately 155,000-acre feet per year of water or 30 percent of the water that comes in through structures. This water loss will be made up by increased flows through the S-5A station and Stormwater Treatment Area 1-E and/or reduction in outflows from the refuge. Without this compensation the refuge will be greatly impacted. Occasionally, the refuge receives water by gravity from S-5A(S), a two-bay gated spillway.

Of all the water coming into the refuge, 44 percent is artificially pumped and the remaining 56 percent is natural rainfall. Approximately 91 percent of the pumped water is drained from agricultural lands north and west of the refuge, while the remainder, 9 percent, is from agricultural and developed lands located east of the refuge through the ACME Stations (*Figure 6*). The pumping stations remove an average of 3/4 of an inch of agricultural area runoff per day from their respective drainage areas in the Everglades Agricultural Area.

Figure 5. Major canals of the Central and South Florida Project which affect water flow in and out of A.R.M. Loxahatchee National Wildlife Refuge and the rest of the Everglades Ecosystem

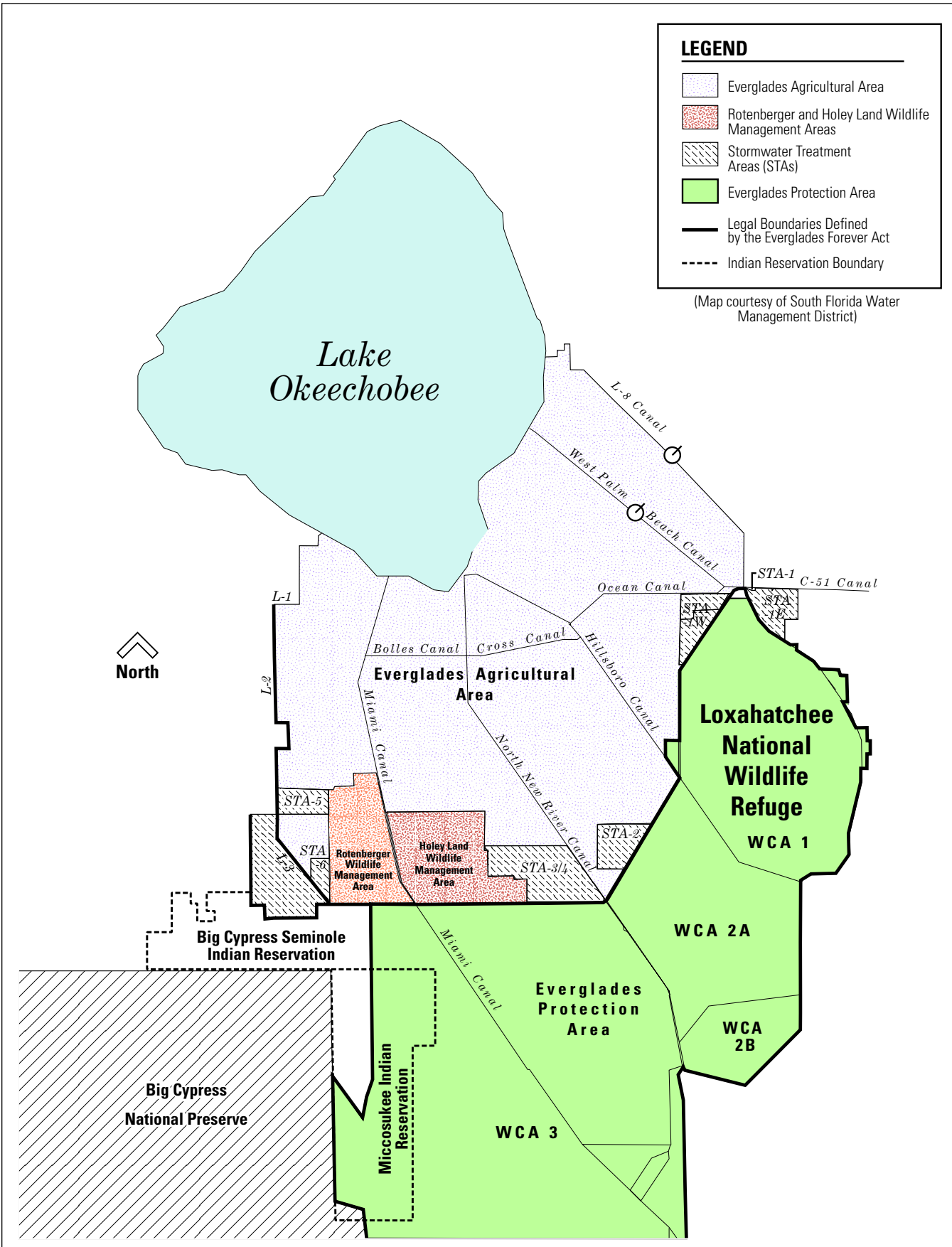
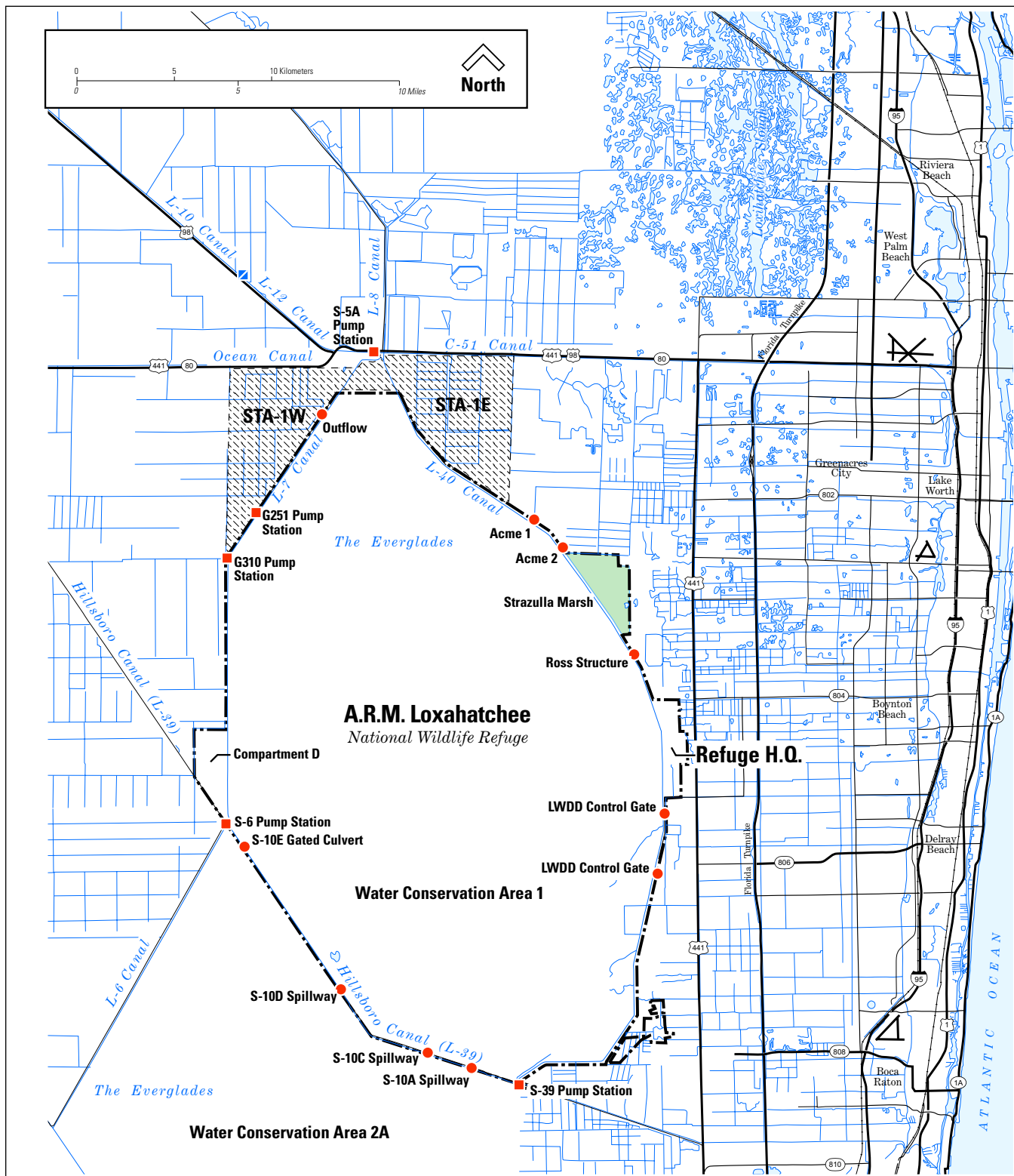


Figure 6. The location of pump stations and spillways at A.R.M. Loxahatchee National Wildlife Refuge



Water Release:

Water outlets from the refuge are the Lake Worth Drainage District and ACME Stations on the east side of the refuge and the S-10 and S-39 spillways on the west side. Serving as a flood control gate, the S-10 consists of three spillways--S-10A, S-10C, and S-10D. In addition, the South Florida Water Management District operates S-10E, which consists of three 6-foot diameter gated culverts, as an additional outlet from Water Conservation Area 1 into Area 2A.

The primary purpose of the S-39 spillway is to make releases from the refuge to supply water needs to the Hillsboro Canal during the dry season. It also can be used to discharge excess water to the ocean when capacity is available in the Hillsboro Canal and when the water is not needed in Water Conservation Area 2 or 3. Water may also be released from the refuge through S-5A north for irrigation in the Everglades Agricultural Area when stages in canals in the C-51, L-10, L-12 or L-8 basins are low.

It is important to point out that both pumping in or release of water at a maximum volume is usually detrimental to breeding wildlife populations. Rapid changes in water depths do not allow some types of animals to reproduce successfully. For example, the primary food source for the

endangered Everglades snail kite is the apple snail. This invertebrate crawls out of the water and lays eggs on herbaceous plant stems. If water rapidly rises, the eggs are submerged and they die. Thus a season's worth of food supply will be lost for limpkins, alligators and other wildlife including the Everglades snail kite. If water levels fall too rapidly, fish populations may not be able to find sloughs or deeper water areas. The fish get stranded and die; a major component of the marsh food web is reduced and large populations of wildlife have insufficient food supplies.

Refuge Water Regulation Schedule
As indicated earlier, the water level in Water Conservation Area 1 is regulated to produce maximum

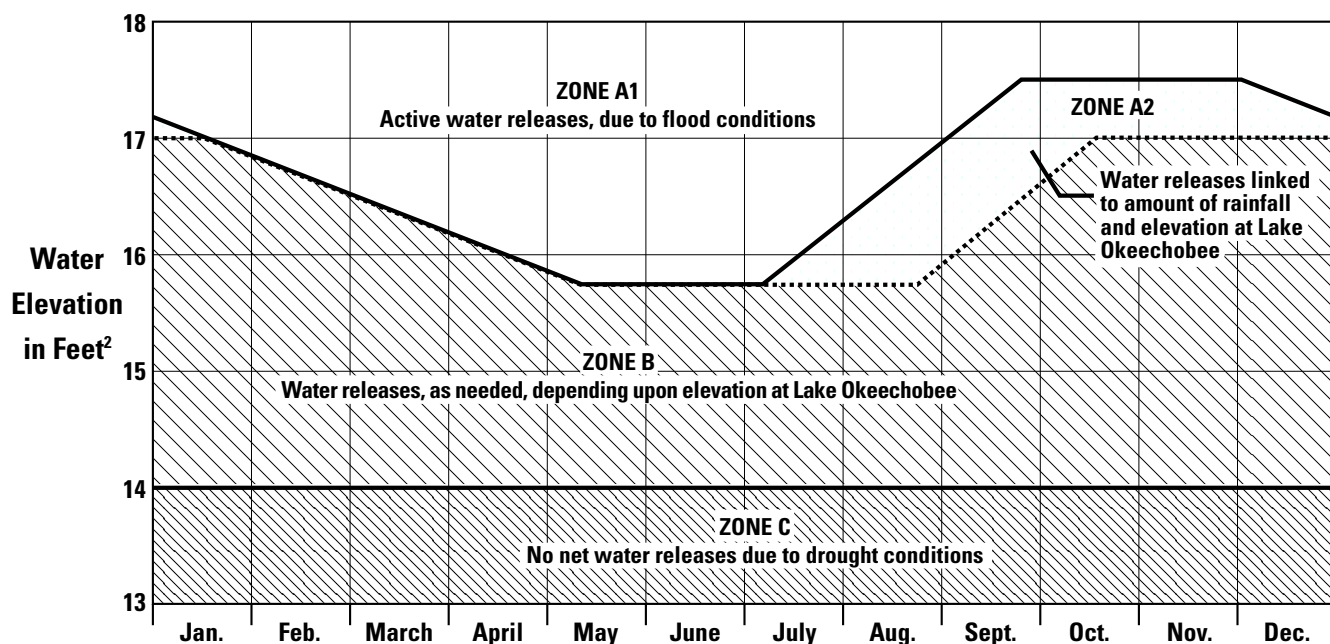
benefits among the various interests--flood control, water supply, fish and wildlife, and prevention of salt water intrusion. To produce these benefits, the water level in the refuge is adjusted as the year progresses, either by a release of water from Water Conservation Area 1, an intake of water from Lake Okeechobee, or by a combination of water release and intake. The particular action taken to release, intake, or retain water is dependent upon the water elevation in a given month. Water elevations, grouped into four zones--A1 (Flood Control); A2, B (Water Supply); and C (Inactive) across time, comprise the water regulation schedule (*Figure 7*).

Zone A1 is the flood control zone from January through June. When water levels enter this zone, active water releases will be made due to flood conditions. If, for example, the water level reached 17.5 feet in January, water would be released through the S-10 spillway to achieve an elevation of 17.2 feet or lower.

From July through December, attempts are made to maintain water levels within Zone A2. In this zone, water levels in Water Conservation Area 1, which are linked with rainfall amounts and the water level at Lake Okeechobee, are permitted to reach a maximum of 17.5 feet; "excess" water



Water management at Compartment D
USFWS Photo by B. Thomas Jr.

Figure 7. Water regulation schedule for Water Conservation Area 1, A.R.M. Loxaxatchee National Wildlife Refuge¹

¹ Established in May, 1995, the water regulation schedule is administered by the U.S. Army Corps of Engineers

² National Geodetic Vertical Datum; Surface water elevation above sea level

is released from the S-10 and S-39 spillways. When additional water is needed for Water Conservation Area 2A or other areas, it is released from Area 1, depending on relative water level at Lake Okeechobee.

Zone B, the water supply zone, ranges from a minimum of 14.0 to 17.5 feet during the year. This is the zone targeted to be most beneficial to fish and wildlife on the refuge. When Area 1 water levels are within this zone, water supply releases are made from Area 1 as needed, in relation to the water level at Lake Okeechobee.

For Zone C, when water levels drop to 14.0 feet or less, there would be no net release of water from Area 1. Any water supply releases would be preceded by an equivalent volume of inflow from the lake.

There have been temporary deviations from the regulation schedule during excessive rainfall events that occurred in 1995, during the El Niño event that occurred during the dry season, January through mid-May 1998, and after Hurricane Irene in the fall of 1999. This allowed water to be stored in Water Conservation Area 1, as well as A2.

Benefits of Water Regulation Schedule:

The refuge water regulation schedule is designed to generate the following benefits to fish and wildlife and their habitats:

- Increased water depth during the wet years in the northern portion of the refuge;
- Increased hydroperiod of interior marshes to avoid annual dryout;
- Increased area of interior marsh which serves as nursery areas for aquatic organisms;
- Improvement in timing of winter stage drawdown to benefit wading birds;
- Restoration of deep water habitats suitable for nesting Everglades snail kites;
- Greater water storage within the central and southern Florida project system during wet and normal rainfall years;

Water Quality

Due to human activities during the last century, nutrients and toxic substances are ubiquitous and an ever-increasing problem in the south Florida environment. Nutrients and toxic substances from urban and agricultural lands have degraded the relatively pristine lakes, streams, estuaries, and bays of the region (McPherson and Halley 1997).

Nutrients:

Impacts on the Everglades

Fertilizers are widely used in south Florida to maintain high levels of agricultural productivity. From July 1990 through June 1991, fertilizers sold in south Florida contained 140,000 tons of inorganic nitrogen and 56,000 tons of phosphate (McPherson and Halley 1997). Nutrient loading from urban areas and the Everglades Agricultural Area has significantly increased nutrient concentrations, particularly phosphorus, in the water conservation areas (Stober et al., 1996). Historically, the Everglades has been deficient in nutrients with phosphorus concentrations averaging 10 parts per billion (Lodge 1994); if phosphorus exceeds 50 parts per billion in the water conservation areas, there is a good chance that eutrophication will occur.

Researchers have documented a variety of negative effects from increased nutrients such as increased soil phosphorus content; changed periphyton communities; loss of native sawgrass communities; increased organic matter in water; reduced dissolved oxygen; conversion of wet prairie plant communities to cattails; and loss of important habitats for wading birds (Stober et al., 1996).

As indicated earlier, approximately 91 percent of the water pumped into the refuge is drained from agricultural lands and developed lands east of the refuge. High nutrient runoff (specifically phosphorus) from agricultural lands is one of the most serious issues facing the refuge; this runoff causes proliferation of cattails and other undesirable plant species that negatively affect the ecosystem's balance. Areas in the western, southwestern, southern, and southeastern portions of the refuge continue to be eutrophied by the influx of nutrients (Fish and Wildlife Service 1996a).

The refuge is unique in that most of the high nutrient water received remains in the canals which surround the conservation area, instead of flowing directly through the refuge itself. Some high nutrient water does move into the refuge, but evidence indicates that it moves slowly and affects only a limited distance of Everglades habitat near the canals (McCormick, 1999). Much of the interior refuge water comes from rainfall. Portions of Water Conservation Areas 2 and 3, and even Everglades National Park, have been directly impacted through runoff entering into the central portions of these areas.

The refuge's water quality contrasts sharply with other Everglades habitats. Using data from the Everglades Consolidated Report, the refuge water quality differs (is lower) considerably from Water Conservation Area 2 with regard to the following: alkalinity (by a factor of 5), specific conductivity (by a factor of 5), ammonia (by 63 percent), nitrate (by more than 50 percent), calcium (by a factor of 5), magnesium (by a factor of 6), sodium (by 478 percent), sulfate (by a factor of 16), chloride (by a factor of 5), and dissolved organic carbon (by 200 percent). However, the refuge has more than twice the amount of iron as Water Conservation Area 2, and this was listed as a concern in the report.

Comparison of phosphorus and nitrogen loadings (metric tons) as a percentage from water years 1990-1999 (South Florida Water Management District 2000).

Area	Mean Phosphorus Load	Mean Nitrogen Load
Refuge	35 %	28 %
Water Conservation Area 2	23 %	21 %
Water Conservation Area 3	37 %	33 %
Everglades National Park	5 %	18 %

When comparing the sizes of the refuge with Water Conservation Area 3 and the Everglades National Park, the refuge takes in much more phosphorus and nitrogen per acre.

Extensive cattail marshes are associated with chemical and hydrologic imbalances derived from agriculture, or other impacted runoff waters (Gleason et al., 1975). While cattails are not described in historical accounts, or identified on early maps of the Everglades, cattails currently occupy at least 6,000 acres of the refuge (Richardson et al., 1990); they are also a persistent noxious weed in compartments, impoundments, and borrow canals. The water used to regulate these areas originates from the L-40 canal and is nutrient-rich, thereby contributing to the spread of cattail. Thick stands of cattail obstruct wildlife use of these wetlands and preclude wildlife-dependent recreation such as birding and photography.

Legal Action

In view of the adverse effects of nutrients on the Everglades, in 1988 the U.S. Attorney for South Florida filed a lawsuit on behalf of the refuge and Everglades National Park. The suit alleged that the State of Florida, by neglecting to enforce its water quality standards, allowed high nutrient runoff to enter Class III waters. In 1991, the State of Florida and the Federal Government signed a Settlement Agreement which mandated the development of a constructed wetland Everglades Nutrient Removal project and six stormwater treatment areas to filter nutrient-rich water; the application of Best Management Practices by farmers to reduce the amount of nutrients originating from their lands, and the research and development of supplemental technologies to enable water to meet the Class III standard.

As indicated earlier, historic phosphorous loading in the northern Everglades is believed to have averaged about 10 parts per billion over time. To attain interim and long-term phosphorus targets, the South Florida Water Management District constructed in 1994, as a test method of removing phosphorous loads, a 3,700-acre wetland known as the Everglades Nutrient Removal Project. This project achieved its performance objectives based on 57 months of operational data (August 94-April 99). All 12-month rolling, flow weighted total phosphorus concentrations at the outflow were well below 50 PPB (Chimney et al., 2000). This project makes an important contribution toward water quality and the stormwater treatment areas are based on this project.

Thus far, two of the six stormwater treatment areas have been completed. The Everglades Nutrient Removal Project is being incorporated into the footprint of a larger Stormwater Treatment Area (1W) for a total treatment area of 6,700 acres. Stormwater Treatment Area 1E, being constructed by the Corps of Engineers, will be 5,350 acres. Together, the stormwater treatment areas will straddle the north end of the refuge filtering water being pumped from the S5A station. These two filtering marshes, along with agricultural best management practices, will reduce phosphorous values to an interim value less than 50 PPB. Long-term values to be set by the Florida Environmental Regulatory Commission will be accomplished through a combination of Best Management Practices, optimization of the stormwater treatment areas, and appropriate new technologies. The successful construction, maintenance, and operation of stormwater treatment areas will be critical to ensuring water quality and quantity to the refuge.

Toxic Materials:

Pesticides and Herbicides

Pesticides have been widely used in south Florida's agricultural and urban areas to control insects, fungi, and other undesirable organisms. Since Florida has year-round warm temperatures and a moist climate, vigorous pest control is a necessity. Pesticide use per acre is ranked among the top five in the nation; at the same time, agricultural production only ranks 30th in the nation.

Pesticides vary in their toxicity, transport, and persistence. While persistent pesticides (e.g., DDT, chlordane, dieldrin, and aldrin) have been banned from Florida, their residues often become widely distributed and are potentially hazardous to non-target biota (McPherson and Halley 1997). By far the most frequently detected insecticides in both surface waters and bottom sediments are the chlorinated hydrocarbons (Shahane 1994). Since the late 1960s, persistent organochlorine pesticides have been detected in fish, which are part of the Everglades food chain (Kolipinski and Higer 1969, McPherson 1973, Haag and McPherson 1997).

Chlorinated chemicals, such as polychlorinated biphenyls, dioxins, and furans, which are used primarily in urban and industrial areas, pose a serious threat not only to fish and wildlife but also to human populations (Colborn et al., 1993). Although most uses of polychlorinated biphenyls have been banned since the late 1970s, these persistent chemicals are still found in the environment. In recent years, many organochlorine pesticides and polychlorinated biphenyls have been linked to hormone disruption and reproductive problems in aquatic invertebrates, fishes, birds, and mammals (Colborn et al., 1993).

Herbicides, including atrazine, bromocil, simazine, 2-4-D, ametryn, hexazinone, and diuron, which have the highest rate of application, are among the most frequently detected herbicides in Florida's surface waters (Shahane 1994).

While the refuge shares the same challenges regarding some pesticides with other Water Conservation Areas and Everglades National Park, those pesticides of potential concern mainly for the refuge include endosulfan, diuron, endosulfan sulfate, and 2, 4-D. Three metals of concern for the refuge include beryllium, iron, and mercury.

Mercury

Evidence of mercury contamination in fish and wildlife in south Florida fresh water ecosystems is extensive. High mercury levels have been detected in the endangered wood stork and other birds (Sundlof et al., 1994). Scientists suspect that increased mercury exposure may partially explain the 50-year decline in wading bird numbers. Fish and alligators sampled in the Everglades have high mercury levels in their tissues (Ware et al., 1990, Eisler 1987). In 1989, after discovering the extent and severity of mercury in fish, the Florida State Health Officer advised fishermen to avoid consumption of several species of fish in more than 1,000,000 acres of the Everglades. The health advisory for the refuge is as follows:

"The Florida Department of Health and Rehabilitative Services has issued a health advisory urging limited consumption of largemouth bass and warmouth caught in certain portions of the Everglades due to excessive accumulation of the element mercury. Fish caught in Water Conservation Area 1 should not be eaten more than once per week by adults and not more than once per month by children under 15 and pregnant women, and fish caught in Water Conservation Areas 2 and 3 should not be eaten at all."

Air Quality

Air quality is not perceived to be as critical a concern as water quality. However, research shows that some of the mercury in the Everglades, generated from incinerators or power plants, is transported there atmospherically.

Biological Environment

Native Vegetation

Vegetative Communities

The native vegetative communities of the Everglades ecosystem found on the refuge include sloughs, wet prairies, sawgrass, tree islands, cattail, and Cypress swamp. Based on 1989 satellite imagery for the refuge interior, these communities have been grouped into four groups, namely, marsh, shrubs, tree islands, and cattail (*Figure 8*). These communities evolved in a watery system that naturally had low nutrients. Numerous algae species or periphyton growing on the submerged vegetation are the basis for all aquatic life, providing food for a host of micro and macro invertebrates and grazing fish species (Lodge 1994).

Sloughs

Sloughs are the deepest natural marsh communities in the Everglades. During the rainy season, water depth in sloughs may exceed 3 feet, with the annual average depth about 1 foot. The dominant vegetation includes white water lily, floating heart, and spatterdock (Lodge 1994). Submergent plants such as bladderwort, fanwort or chara are abundant (Fish and Wildlife Service 1997c). Underlying sloughs is peat soil, which support fish species and aquatic invertebrates.

Wet Prairies

In contrast to sloughs, wet prairies have shallower water levels and are characterized by short emergent plants such as beakrushes, spike rushes and red-root (Chapman, pers. comm.). Wet prairies are the most prevalent vegetative community (approximately 50 percent land coverage) in much of the central and eastern portions of the refuge, and are generally found between sawgrass marshes and sloughs. This important vegetative community provides prey for wading birds and the Everglades snail kite in the form of fish, aquatic invertebrates and apple snails (Lodge 1994).

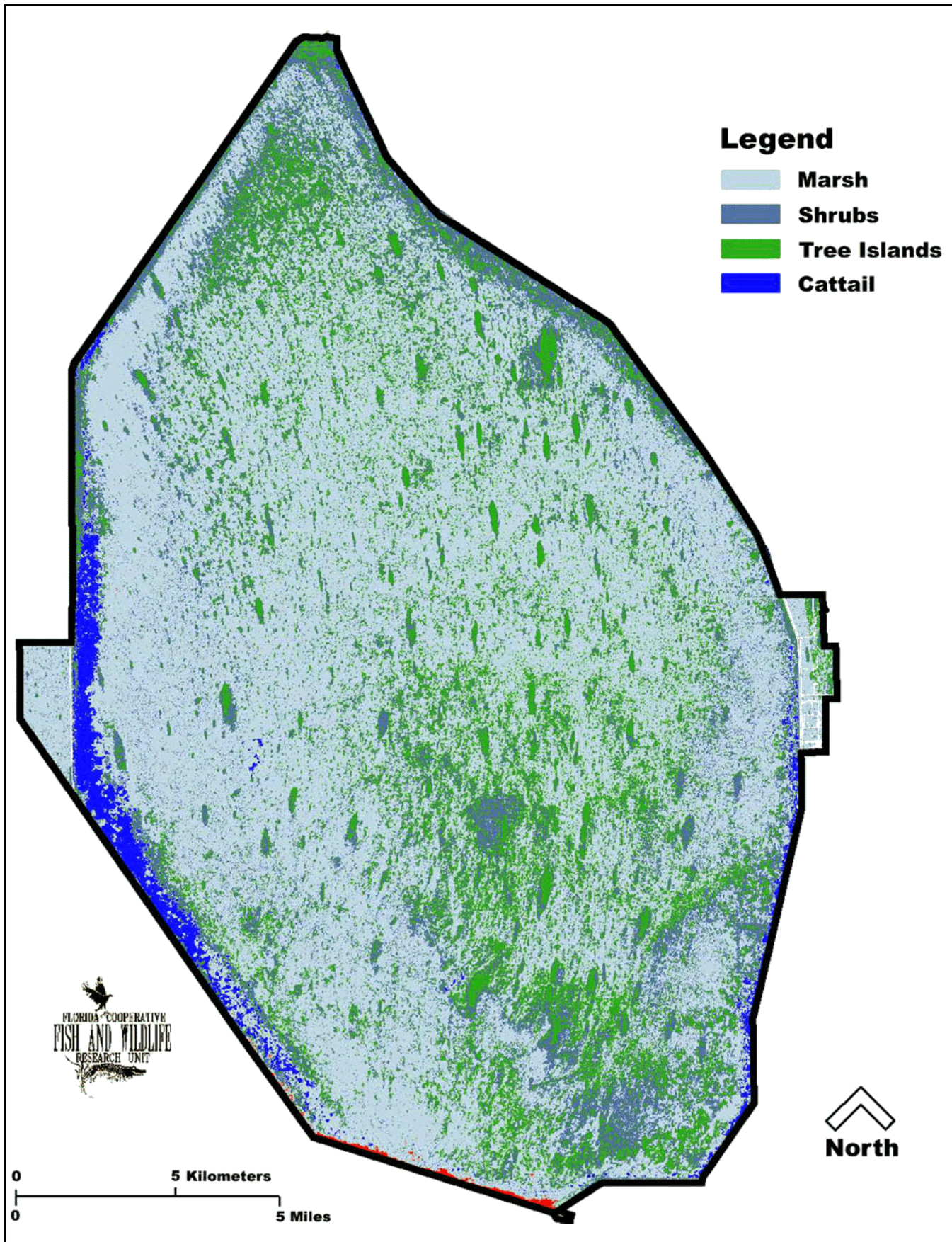
Sawgrass

The sawgrass community (25 percent land coverage) is characterized by the saw-edged sedge that dominates this type of habitat. Sawgrass may grow in solid stands, mosaics or interspersed with other species such as wax myrtle and dahoon holly. Sawgrass areas often border tree islands, separating them from the wet prairie (Lodge 1994).

Tree Islands

The northern portion of the refuge is characterized with thousands of tree islands that range from less than 1 acre to more than 300 acres. There is approximately 20 percent of the refuge interior covered with tree islands. They are typically composed of an overstory of redbay and dahoon holly with wax myrtle, buttonbush and cocoplum comprising a dense midstory and numerous ferns in the understory. Tree islands form when submerged peat patches rise to the water's surface and small plants become established followed by shrubs and trees. During drought conditions, alligators wallow out a circular deep water refugia, called "alligator holes." Wind blown herbaceous seeds germinate on the exposed peat and eventually woody vegetation grows on the edges and creates a tree island with a "doughnut shape." Alligator holes are very important aquatic refugia during the dry season and are sources for fish and other aquatic organisms' population reestablishment after summer rain rehydrates the ecosystem (Lodge 1994). A vast number of tree islands have been impacted by invasive exotic plants.

Figure 8. Vegetative communities of A.R.M. Loxahatchee National Wildlife Refuge
(Adapted from Richardson et al., 1990)



Cypress Swamp

On the eastern edge of the refuge is a 400-acre cypress swamp community which is composed of pond cypress trees, pond apple, myrsine, lichens and ferns such as giant leather, sword, shield, strap, royal, resurrection and swamp ferns. The moist microclimate of the cypress swamp also provides for a profusion of epiphytes (air plants), such as cardinal, giant, reflexed and twisted wild pine and Spanish moss. This cypress swamp is the largest remaining remnant of a community on the east side of the Everglades whose former range extended from Lake Okeechobee through Palm Beach and northern Broward counties, south to Fort Lauderdale (Lodge 1994). The cypress swamp includes 20 species of trees and shrubs, 20 herbs, 9 vines, 1 sedge, 14 ferns, 7 bromeliads and 2 lichens (Fish and Wildlife Service 1987b). (*See Appendix K*).

Cattail

Two native species of cattail grow on the refuge. Naturally growing cattails can be found surrounding wading bird colonies, roost tree islands, and alligator holes. The cattail growth is dependent upon the intense pulse of nutrients deposited by the concentration of nesting birds. After a tree island is abandoned by nesting birds, cattails often die back because of the loss of nutrients (Fish and Wildlife Service 1998c). In response to years of artificially high levels of nutrients (phosphorous) in the water, a dense stand of cattails has been established along the perimeter canal. Near the S-6 water structure, monotypic stands of cattail growth are approximately ½ mile deep. This water, received from the S-5A and S-6 pump stations, originates from the agricultural fields to the north and west of the refuge. Attempts to reduce the nutrient load in water and lessen the negative impacts to the refuge are on-going (*see Part II, Significant Resource Problems and Part III, Water Quality*).

Wildflowers

At least 50 wildflower species (exotic and native) can be found in marsh areas of the refuge (Fish and Wildlife Service 1987). Common types found are Spanish needle, arrowhead, buttonbush, string and spider lilies, elderberry, lizard's tail and scorpiontail, pickerelweed and primrose willow.

Exotic Plants

Invasive exotic plants, such as Brazilian pepper, melaleuca, and Old World climbing fern, pose a serious threat to the whole south Florida ecosystem, to native plant communities, wildlife habitats, threatened and endangered species, and species of special concern on the refuge. Floating exotic plants, such as water lettuce and water hyacinth, threaten to clog refuge canals restricting navigation, water flow, and water drainage. These alien plants, lacking natural predators and insects to keep them in check, rapidly expand forming dense, monotypic forests and thickets which are undesirable to humans and wildlife. This degraded habitat has been proven to support less species diversity than native plant habitats. Generally, exotic plants in south Florida tend to establish in "disturbed" areas such as abandoned farm fields, along roadways, canals, and drainage ditches, and in wetlands which have been altered or stressed due to hydroperiod changes (Ferriter 1998). Melaleuca and Old World climbing fern are, however, not restricted to areas of disturbance. Since the climate and conditions of south Florida are similar to conditions for melaleuca and Old World climbing fern in their native countries, these plants have rapidly become established in pristine areas. Management of invasive pest plants is one of the priorities established by the South Florida Ecosystem Restoration Task Force. As a result of these priorities, the task force and working group have authorized and funded the Noxious Exotic Weed Task Team to develop the comprehensive strategic plan for the management of exotic pest plants in Florida (with emphasis on south Florida). The team members are managers and scientists from key federal, state, and local agencies that deal directly with exotic pest plants (Doren 1998). The State of Florida Everglades Forever Act of 1994, requires the South Florida Water

Management District to coordinate with other state, local, and federal government entities to manage exotic pest plants with emphasis in the Everglades Protection Area (all areas from the Everglades Agricultural Area south to the Everglades National Park). The Florida Chapter of Exotic Pest Plant Council, established in 1982, documents the spread of exotic pest plants and unifies the exchange of information between land management agencies, research scientists, industry and other interest groups who are concerned with the impacts of exotic plants in natural areas (Laroche 1994). Category I plants are species that are currently invading and disrupting native plant communities in Florida. The refuge has 21 Category I plants (Table 24). Category II plants are species that have shown a potential to disrupt native plant communities, and the refuge has at least nine of these (Table 25).

Refuge staff will remain actively involved with organizations such as the Florida Exotic Pest Plant Council, Southeast Florida Exotic Pest Plant Council, and the South Florida Invasive Plant Working Group and adopt the strategies for exotic plant management recommended by these organizations. The refuge will update its melaleuca management plan by 2002 to incorporate the methods and strategies of the South Florida Water Management District's melaleuca management plan originally drafted in 1990. By following the strategies of this plan, the South Florida Water Management District has almost completed initial treatments of melaleuca on all their lands and surveys have indicated a 26 percent decrease in melaleuca populations particularly in the water conservation areas and Lake Okeechobee from a high of 488,000 acres in 1993, to 361,000 acres in 1999.

Melaleuca

Melaleuca, a native of Australia, was originally introduced in southeast and southwest Florida in 1906 (Meskimen 1962) as an ornamental plant. At one time, people believed the tree could assist in draining water from the Everglades because water is rapidly taken up, used in photosynthesis and released into the air as a vapor (transpiration). It is thought that the area that became the refuge and Ft. Meyers on Florida's west coast were heavily

seeded by airplane. In the 1930s and 1940s, trees were planted along the rim canal of Lake Okeechobee and at the Monroe station, Big Cypress National Preserve (Laroche 1994). Although the greatest concentrations are found in areas of historical introductions, the refuge has one of the highest concentrations of melaleuca in all of the south Florida ecosystem.

In Strazzulla Marsh, melaleuca has invaded the cypress swamp and domes, sawgrass, and wet prairies; nearly 50 percent of this area has been affected. In the refuge interior, melaleuca has invaded native tree islands, sawgrass, sloughs, and wet prairies. The most recent aerial survey in 1995, estimated that 49 percent (71,000 acres) of the refuge interior was moderately to heavily



Melaleuca "hack and squirt"
Photo © John and Karen Hollingsworth

infested. Using 1992 data as a comparison, melaleuca is calculated to be expanding at the rate of 10 acres per day. The history of melaleuca throughout the Everglades ecosystem, including the refuge, is one of "an explosion in slow motion" (Laroche 1994). From the 1960s to the early 1980s, melaleuca grew at an exponential rate. Areas occupied by a single, isolated "pioneer" tree soon developed into acres of dense "heads" and

Figure 9. 1992 Melaleuca Aerial Survey Results

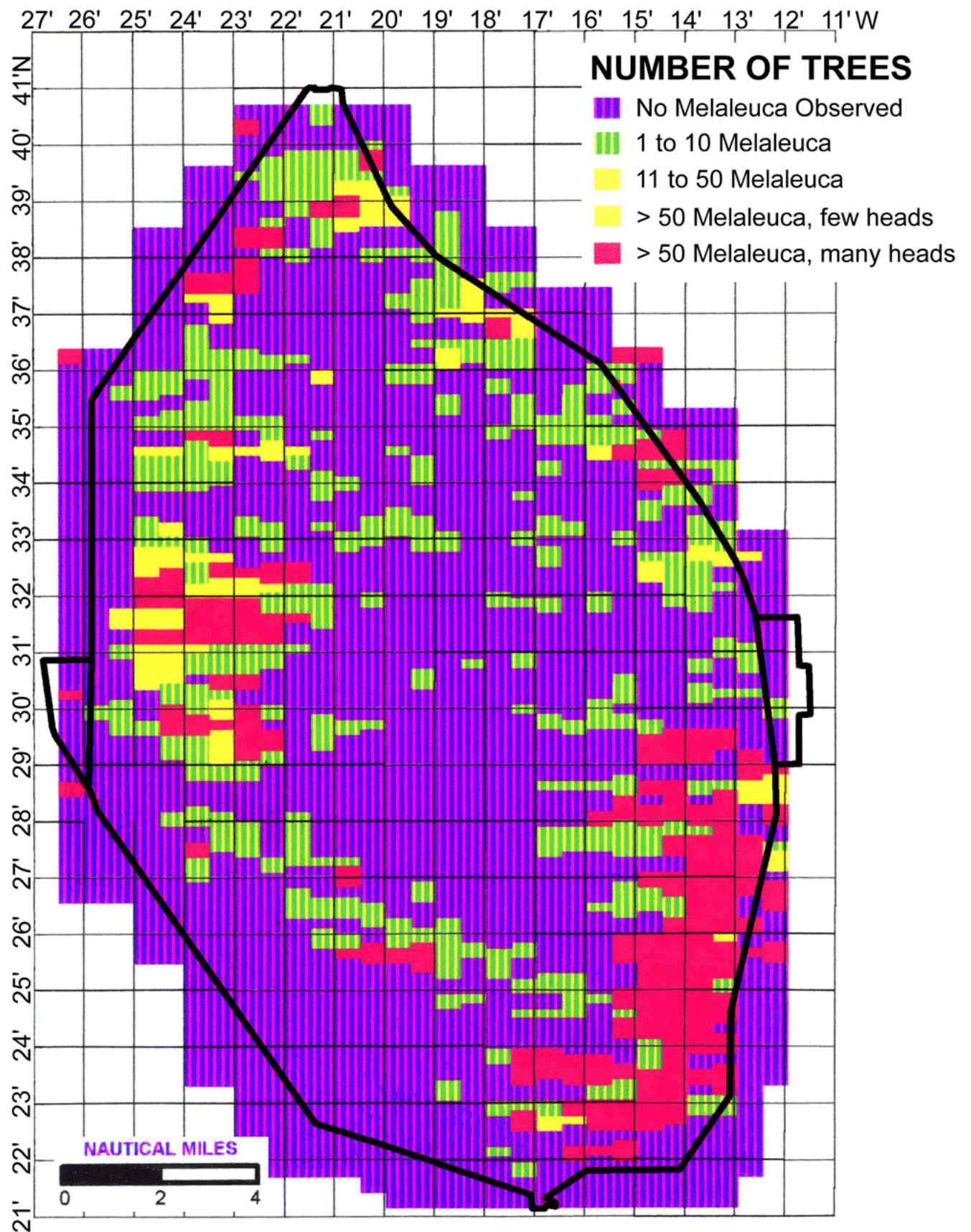
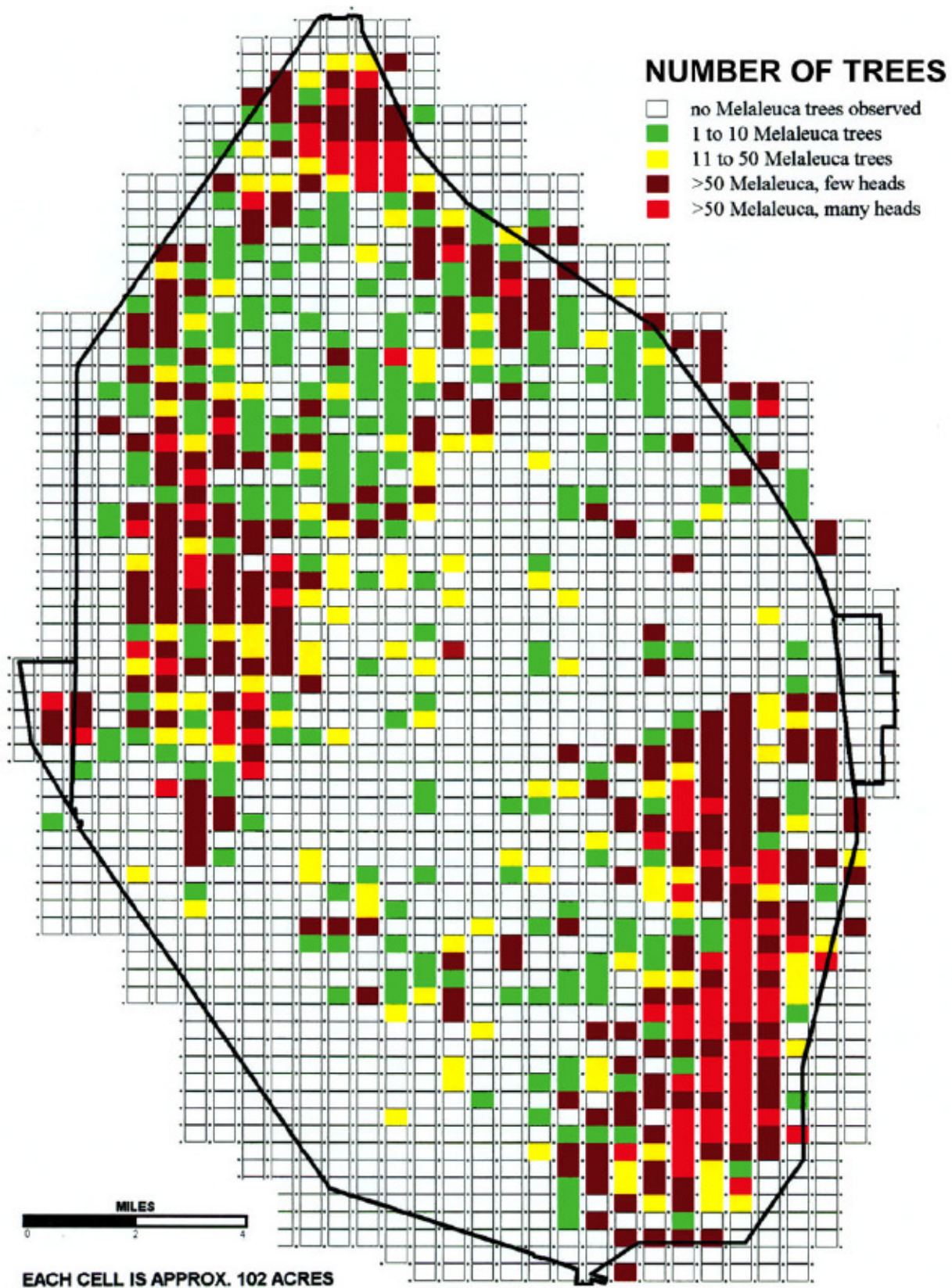


Figure 10. 1995 Melaleuca Aerial Survey Results



monotypic forests. By the mid- to late-1970s, melaleuca had spread to all areas of the refuge. It was the Refuge Manager's opinion that if an effective treatment technique could not be found, melaleuca would certainly take over the refuge.

With no natural enemies in south Florida, such as disease or insects to control its spread, and an ideal growing climate, melaleuca now threatens to permanently replace and eliminate native Everglades flora and fauna. As indicated above, melaleuca primarily invades disturbed areas but is particularly prevalent in Florida wetlands; i.e., the refuge, where hydroperiods have been artificially shortened or altered. In addition to the above effects, live melaleuca inhibits the use of prescribed fire as a management tool since the volatile oils in melaleuca leaves would produce intense, uncontrollable fires. Furthermore, the use of fire would generate a massive seedfall which would allow the tree to become quickly established in adjacent areas. The raging wildfire during the drought of 1989-90, certainly contributed to the exponential spread of melaleuca in the refuge interior. The primary management tool used at the refuge for the control of melaleuca is herbicides. At the present time, the chief treatment method involves felling mature trees using chainsaws followed by treatment with 50 percent Arsenal® diluted in water. Follow-up visits are necessary to prevent reinfestation. Since an intensive herbicide program was established in 1992, refuge staff have eradicated more than 2,209,000 of these trees on refuge lands at an annual cost exceeding \$200,000, funded by the Service and the District. An estimated 6,400 acres have been cleared of melaleuca. Unfortunately, refuge staff can only treat about ½- to 1-acre-per-day, which is having a limited effect on the 10-acre-per-day advance of melaleuca on the refuge. Since herbicidal treatments are labor intensive and costly and melaleuca can easily re-infest cleared areas, biological control offers an alternative (Center et al., 1998).

In 1999, the refuge switched to using private contractors for exotic plant control for both melaleuca and Old World climbing fern after refuge staff consulted with the National Park Service, the Department of Environmental Protection, the South Florida Water Management District, and other local agencies and made the determination that using private contractors was the most cost effective means to eradicate exotic plants. To better incorporate the philosophy of an integrated pest management approach, the refuge has increased its role and effort concerning public outreach and awareness by identifying the dangers and risks associated with the introduction of exotic plants. Programs by individuals directly involved with exotic plant management are scheduled as part of the "Calendar of Events" at the visitor center and these presentations are free to the general public. Refuge staff schedule programs and slide presentations for environmental education groups and for local chapters of national organizations such as the Audubon Society.

The refuge will continue to push for more exotic plant control funding, a limiting factor to successful exotic plant management. This will be done by keeping this issue a high priority and informing all levels of the Service about resource impacts and budget needs. Several key refuge personnel serve as members on regional invasive species teams and ecosystem restoration task forces where key exotic plant issues are addressed. The refuge's exotic plant problems are frequently addressed in local and national newspapers, magazines and on national and Service web sites.

Within the past few years, U.S. Department of Agriculture research scientists have begun to research insects from Australia as possible controls of melaleuca. The snout beetle, was released on the refuge and other parts of south Florida in the spring of 1997. Unfortunately the beetle cannot survive and reproduce in the wet habitat of the refuge. A second biological control, the defoliating sawfly, is scheduled for release in 2000. Shipments were sent to the quarantine facility in 1992-1993. The Environmental Assessment is currently being reviewed pending approval

by the Service's Washington Office. This sawfly offers the best hope for melaleuca control. Both adults and larvae feed voraciously on foliage of the tree eventually causing complete de-foliage. The insects entire life cycle occurs on the melaleuca tree, above ground. Larva pupate within the bark of the tree. Researchers have been reluctant to release this insect due to its noticeable damage as many people still have melaleuca growing in their yards as ornamentals. Additionally, its release has been delayed because the larvae have proven to be toxic, when consumed in large quantities, by some wildlife and domestic animals. Studies and research into this matter are continuing at this time. Evidently the larvae store a toxic chemical in their system as they feed (Lophrytonin) and it becomes more concentrated as they age.

Alternative methods for exotic plant control on the refuge other than chemical, physical, and biological controls are currently limited. Mechanical control using heavy equipment is limited to impoundment levees where the primary target is Brazilian pepper. No heavy equipment can be used in sensitive areas such as the marsh interior or in Strazzulla Marsh due to the soft substrate and irreparable damage this machinery would cause to native vegetation. As funding permits the refuge will use aerial treatment as a control method on some of the larger monotypic melaleuca heads. This application technique has proven effective by the South Florida Water Management District in the water conservation areas and on Lake Okeechobee. The refuge would rank at the top of the list for funding from the District and Florida Department of Environmental Protection programs due to its designation as a water conservation area and its close association with the District.

Public use volunteers, environmental education groups, and college students currently assist refuge staff in the removal of Brazilian pepper, willow, and cattail in refuge compartments, along the trails and levees, and around the visitor center. Groups of college students have, in the past, assisted refuge crews by pulling melaleuca seedlings. The logistics involved with the transport of large numbers of individuals into the marsh interior for exotic plant control is not effective given current refuge staffing levels and available equipment. All funding has focused on exotic plant control contracts.

Ultimate control of melaleuca at the refuge will depend on an integrated management approach using both chemical and biological methods (e.g., defoliating sawfly and melaleuca snout beetle). In combination, these efforts will certainly slow the establishment of additional areas of infestation. Without continued management, the refuge and its unique northern Everglades habitat will surely be lost to melaleuca.

Old World Climbing Fern

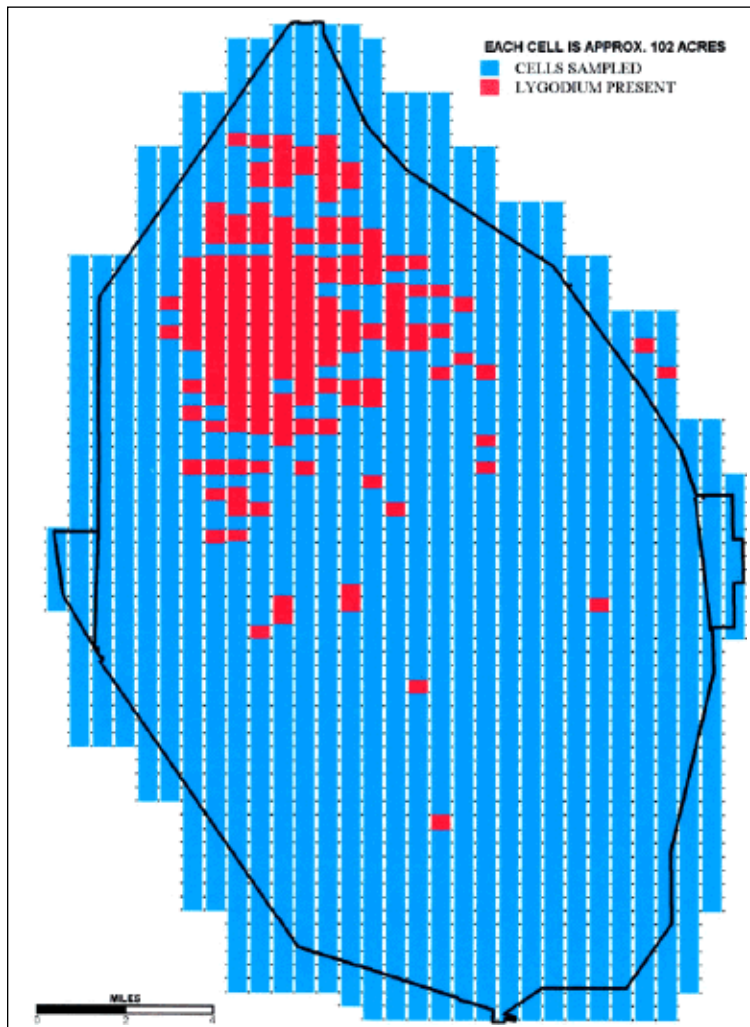
Old World climbing fern, a native of Asia, was first found in Martin County in the late 1950s (Beckner 1968). This species prefers wet sites and grows particularly well along the ecotone between wet and dry habitats. It also appears to be growing particularly well in areas where native tree islands were damaged, or killed by a refuge fire during 1989-1990. Ascending tree canopies, it smothers Everglades tree islands, invades pinelands and cypress swamps, and also spreads across open wetland marshes (Ferriter 1998). Evidently, extended hydroperiods have no noticeable impacts on the growth or spread of the fern.

On the refuge, Old World climbing fern is overrunning native tree islands in the interior and is commonly found in the Cypress Swamp. In a number of locations, "fern ladders" can be seen ascending to the top of cypress trees. Its presence on trees and their canopies prohibits the use of prescribed fire as a management tool in the cypress swamp and on interior tree islands, where a crown fire would be particularly destructive. A 1995 aerial survey by the South Florida Water Management District revealed that 17,500 acres (12 percent) of the refuge were infested by climbing fern.



*Refuge volunteers working to control exotic plants
USFWS Photo by L. Chapman*

Figure 11. 1992 Old World Climbing Fern (*Lygodium*) Survey Results



By 1997, it had infested an estimated 21,000 acres. Some areas are heavily impacted and others are moderately to lightly impacted. However, since small areas of fern infestation are not visible in aerial surveys, the estimate is considered conservative.

Unfortunately, no standard control programs currently exist for the treatment of Old World climbing fern throughout south Florida. Refuge staff have been hand pulling small clumps of climbing fern from the Cypress Swamp and along the Marsh Trail. In collaboration with the South Florida Water Management District, test plots have been established in the refuge interior to monitor the spread of the fern. The U.S. Department of Agriculture and Geological Survey have begun research to find safe and effective biocontrols.

The Southeast Florida Exotic Plant Task Force and Florida Department of Environmental Protection have joined the refuge in an effort to control exotic plants in south Florida. In 1999, a contractor began the first ever treatment of Old World climbing fern and was able to treat 300 acres in the refuge interior. This work signifies the first effort to control this invasive exotic plant on the refuge.

Exotic plant populations, size, and distribution will continue to be monitored using systematic aerial surveillance and reconnaissance flights at a minimum of every three years. The last survey was conducted in 1995, for melaleuca and Old World climbing fern populations. Similar surveys were conducted in 1990 and 1992. Data collected during these flights will be used to create distribution maps, and refuge biologists will be able to calculate expansion rates and document infestation levels of exotic plants. These surveys will also help to determine the effectiveness of the melaleuca and Old World climbing fern herbicide treatment programs. A surveillance and reconnaissance flight survey is scheduled for September 2000. Individual management

plans for melaleuca and Old World climbing fern will be completed or updated by 2002, and incorporated into an overall Integrated Pest Management Plan.

Without extensive chemical treatment or biocontrols, Old World climbing fern will continue to spread across the refuge, engulfing native tree islands and cypress trees.

Brazilian Pepper

Brazilian pepper was introduced in the late 1800s as an ornamental shrub. This widely adaptable and aggressive shrubby tree rapidly invades disturbed sites such as fencerows, roadsides, canal banks, levee berms, and abandoned farmland. It also invades pine flatwoods, sand-pine scrub, cypress swamps, fresh water marshes, and mangroves. Growth and seed production is stimulated by normal hydroperiods. A tremendous number of seeds are dispersed by fruit-eating birds such as the cedar waxwing, American robin, and European starling, as well as opossums and raccoons. Once established, Brazilian pepper out-competes the slower growing native vegetation, eventually forming monotypic forests. A 1993 aerial

survey revealed that Brazilian pepper infested an estimated 550,000 acres of central and south Florida. By 1997, the acreage infested had grown to 660,000 acres (Ferriter 1998).

Currently, Brazilian pepper ranks as the third most invasive plant found on the refuge. The greatest concentrations of Brazilian pepper are found along compartment levees, roadways, in the Cypress Swamp, and on tree islands in the northern interior where water levels fluctuate. With the exception of the drier interior tree islands, it does not grow well in the refuge interior due to the extended hydroperiod (deep water). Little is known about the extent of Brazilian pepper on the refuge.

Brazilian pepper is currently controlled with herbicides or by mechanical means. Trees located in high visibility or public use areas are targeted first, such as those along the Marsh Trail or around the visitor center. Trees are typically treated using the “cut stump” technique followed by the application of undiluted Rodeo® or 50 percent Arsenal®. Large trees along levee berms and roadways are uprooted mechanically using a backhoe or bulldozer. Post-treatments are necessary to control resprouting from uncut stems. Seedlings are removed by hand. Where permitted, fire can be effective in controlling seedlings. From 1992-1998, refuge staff and volunteers eliminated an estimated 41,000 trees. Without active management, Brazilian pepper will form dense thickets. These thickets will eventually obstruct vehicular and human traffic.

Australian Pine

Australian pine was introduced in the 1890s as a potential lumber source. Later, it was planted around farm fields as windbreaks and along canals to stabilize banks, helping to prevent soil erosion. By the early 1900s, it had already begun to invade natural habitats (Small 1927). By 1993, Australian pine invaded more than 365,000 acres in south Florida (Simberloff et al., 1997). Like Brazilian pepper, Australian pine aggressively invades disturbed areas such as abandoned farm fields and vacant lots, and along roadways and canals. Rapid growth produces dense forests which shade out native plants. According to Ken Langeland of the University of Florida, the accumulated litter (needles) under a dense forest prevents the growth of desirable vegetation. On the refuge, Australian pine is most frequently encountered along the perimeter levee which surrounds the refuge.

As a part of melaleuca control operations, Australian pine is cut and the stump and cambium are treated with a 50 percent solution of Arsenal®. Over a 6-year period from 1992-1998, 90 Australian pines have been eliminated in the refuge interior. Australian pine will continue to be treated when encountered during normal melaleuca eradication efforts. No biological controls have been released for the control of this aggressive tree. The high water level in the refuge interior should help prevent the spread of this tree but drier sites along perimeter levees will have to be monitored closely.

Floating Exotic Plants

Floating exotic plants, such as water hyacinth and water lettuce, form dense mats which clog canals impeding navigation, water drainage, and recreational use. In addition, heavy infestations may retard the growth of desirable submersed plants; lower dissolved oxygen levels; increase the frequency of fish kills; increase sedimentation; increase flooding and water temperatures; and destroy and smother fish and wildlife habitat (Schmitz et al., 1993).

Water hyacinth presents a greater problem than water lettuce. Originally introduced as an aquatic ornamental in the 1880s and as potential cattle fodder, water hyacinth quickly spread throughout Florida's waterways. By the 1950s, it had infested more than 118,000 acres of these waterways (Simberloff et al., 1997). By the 1960s, water hyacinth infested an estimated 125,000 acres (U.S. Congress 1965). Intensive management reduced this acreage to around 3,900 by 1988 (Schardt and Ludlow 1993).

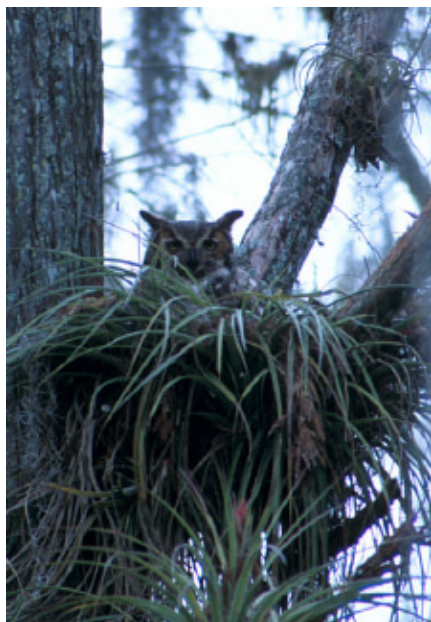


Water hyacinth
Photo © John and Karen Hollingsworth

On the refuge, the acreage of water hyacinth and water lettuce ranges from 250 to 300 acres, depending upon control efforts and time of year. Infestations are restricted to the perimeter canals (L-40, L-39, and L-7) of the refuge interior and borrow canals surrounding refuge compartments and impoundments. Maintenance of the perimeter canals is currently performed by the South Florida Water Management District. Approximately 100 to 200 acres of water hyacinth and water lettuce are treated annually. Using airboats and johnboats for access, herbicides (e.g., Reward® and

Rodeo®) are applied with portable spray units. When infestations impede navigation, water flow and drainage, spraying is applied with helicopters. While the perimeter is maintained by the Water Management District, refuge staff maintain the borrow canals surrounding refuge impoundments, the center canal which serves to drain and fill Compartment C, and the Canoe Trail.

Several insect biocontrols that have proven to be highly effective in reducing the rate of expansion are the water hyacinth weevils (Center 1982), and the water hyacinth moth (Center and Durden 1981). The South American weevil has caused dramatic declines in the water lettuce populations (Dray and Center 1992). The Asian water lettuce moth has yet to become established.



Great horned owl
USFWS Photo

Fish and Wildlife

The refuge contains nearly 150,000 acres of wetlands which provide important feeding, roosting and nesting habitats for many birds, mammals, reptiles and amphibians. These wildlife are described below.

Birds

In any given year, as many as 257 species of birds may use the diverse wetland habitats of the refuge--the sloughs, wet prairies, sawgrass, tree islands, cattail, and cypress swamp. Of those birds, approximately 93 species are considered to be common or abundant during certain seasons (*Table 21*). For the Everglades snail kite, limpkin, smooth-billed ani, roseate spoonbill, wood stork, American swallowtail kite, short-tailed hawk, Florida sandhill crane, purple gallinule, black-necked stilt and the Arctic peregrine falcon, the refuge provides important habitat for both nesting and migration. In its position in the North American Continent, Florida is a "natural funnel" for neotropical migratory birds (e.g., songbirds, raptors, shorebirds), which depend on the refuge and other areas for resting and feeding prior to their long flight to Central and South America. Through the Partners-in-Flight program, federal, state, and private agencies are developing and implementing a comprehensive approach for managing selected species of migratory nongame birds (*Tables 28 and 29*). In an attempt to prevent the listing of most of

these birds as threatened or endangered species, these trust species are given higher priority than general wildlife species in management methods and judging potential impacts. The refuge currently conducts migratory passerine surveys in the woodlands near the visitor center and on the tree islands of the interior.

Waterfowl

A variety of duck species such as the ring-neck, mottled, fulvous-whistling, wood, and ruddy duck, as well as blue-winged teal, green-winged teal, lesser scaup, northern pintail, American widgeon, northern shoveler, hooded merganser, and gadwall may be found on the refuge when water levels are appropriate and adequate habitat is available. However, the mottled and wood ducks are the only ones nesting in the area. Waterfowl counts taken between 1975 and 1982, revealed that the average peak wintering duck population was more than 21,000 birds. More recently (1989-1997), however, the general trends in waterfowl numbers appear to be lower and there is a great deal of within-seasonal and year-to-year variation in waterfowl numbers (*Table 1*). These results are based on total counts taken each month from September-March. Only the lowest and highest counts taken during this period are shown. This decline in waterfowl numbers can be partially explained by the encroachment of cattail, as indicated earlier (see section on water quality), by the increased availability and quality of habitat further north and by mild winters in the north. If the birds do not have to expend the energy, they will not fly as far south as the refuge. The refuge is at the southernmost point of the waterfowl migration area (*Figure 3*). Approximately 20 percent of the refuge is available for waterfowl hunting during season, leaving 80 percent of the refuge for waterfowl to forage and rest.

There are no health advisories for consuming waterfowl collected in the Everglades, and there are no known studies of mercury levels conducted on waterfowl collected at the refuge.

Table 1. Number of waterfowl observed during surveys in the refuge interior from September to March 1989 to 1998

Count	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998
Low	39	3089	97	no data	6	35	48	369	9	212
High	16,000	35,817	15,520	20,000	405	1,201	1,901	1,318	927	1,104

Wading Birds

The wading bird breeding populations of the Everglades ecosystem have declined 90 percent as a result of a more than 50 percent reduction in habitat due to urbanization, agricultural conversion, altered water flows, and the associated reduction in fish and food items. Of the 15 species of waders that breed in the south Florida ecosystem and the refuge, the wood stork, great egret, snowy egret, tricolored heron, and white ibis have declined by an estimated 75 to 80 percent between the 1930s and late 1970s (Ogden 1994). Wading birds foraging on the refuge include the wood stork, little blue heron, tricolored heron, great blue heron, great egret, snowy egret, cattle egret, roseate spoonbill, black-crowned and yellow-crowned night-herons, glossy ibis, and white ibis. Based on annual nesting bird surveys using air boats, there appears to be a slight decline in the number

of nests from 1992 to 1998 (*Table 2*). Generally, wading birds need water levels high enough to sustain fish (prey populations) but low enough to allow them to forage effectively. In 1999, lack of spring rains gradually lowered the refuge interior water levels during breeding season to create excellent nesting conditions. Coupled with a more comprehensive survey method, 1999 resulted in the highest number of nests in recent memory. However, heavy rains caused the water levels to rapidly rise at the time when the chicks fledged, creating difficult foraging conditions for the young birds. Fluctuating water levels strongly influence the nesting success of all birds each year.

Table 2. Wading bird nest estimates on the A.R.M. Loxahatchee National Wildlife Refuge, 1992-1999

<i>Species</i>	<i>1992</i>	<i>1993*</i>	<i>1994</i>	<i>1995</i>	<i>1996</i>	<i>1997</i>	<i>1998</i>	<i>1999</i>
Little blue heron	938	673	1,333	1,153	1,372	1,311	1,036	1,592
Tri-colored heron	520	173	103	343	197	254	352	489
Great blue heron	87	73	73	82	118	95	123	217
Great egret	239	328	396	610	837	516	828	2,037
Snowy egret	97	4	21	59	28	73	15	470
Cattle egret	1,408	728	1,051	729	2,403	1,028	1,682	831
White ibis	2,761	218	1,849	2,249	800	1,095	873	5,780
Total nests	6,050	2,575	4,826	5,225	5,755	4,372	4,909	11,416

**During 1993, approximately 378 unknown wading bird nests could not be identified.*

Mammals

There are 23 species of mammals known to occur on the refuge (Fish and Wildlife Service 1999), including the Mexican free-tailed bat, cotton mouse, grey squirrel, raccoon, bobcat, round-tailed muskrat, and the exotic nine-banded armadillo. At the present time, there are no surveys to monitor population levels for these species.

From 1982-1984, white-tailed deer counts were completed using a helicopter. During those years the number of deer observed ranged from 1 to 80, and the estimated population on the refuge was between 23 and 1540 animals. No recent helicopter surveys have been completed.

Amphibians

Very little is known about the status of various populations of amphibians on the refuge. There are a few known species of salamanders that may occur on the refuge. These are the two-toed amphiuma (or Congo eel), greater and lesser siren, everglades dwarf siren, peninsula newt, and dwarf salamander (Coppin 1997). Great blue herons have been observed eating the sirens or the amphiuma (Fish and Wildlife Service 1999a).

There are at least 11 species (exotic and native) of frogs and toads on the refuge. A few of the most common are the Florida cricket frog, green treefrog, pig frog, oak toad, and southern toad (Coppin 1997). The exotic Cuban tree frog is frequently heard around the headquarters office and visitor center and has been observed in Strazzulla Marsh (Fish and Wildlife Service 1999a).

Reptiles

Approximately 10 species of turtles (exotic and native) use the refuge habitats, including the stinkpot, Florida redbelly, peninsula cooter, and Florida softshell turtles (Coppen 1997). Eight species of lizards (exotic and native) are found on the refuge, including the green anole, the Cuban brown anole, and the ground skink (Coppen 1997). Occasionally, exotics such as monitor lizards and green iguanas have been found on the refuge.

Up to 24 different snake species (exotic and native) have been found on the refuge, including garter snakes, racers, Florida cottonmouth and the dusky pygmy rattlesnake (Coppen 1997). Observed exotic snakes include boa constrictors and pythons.



Everglades rat snake
USFWS Photo by B. Thomas Jr.

Alligators are considered umbrella or keystone species because of the important role they play in providing pockets of standing water during droughts and they are near the top of the food chain.

According to early refuge personnel, the refuge supported more and larger alligators per acre than most parts of the Everglades. During the early 1950s through 1965, there was some concern that alligator populations had decreased due to hunting and few large alligators were observed in the interior (Fish and Wildlife Service 1950-1965). In 1967, a night count around the perimeter canal resulted in the sighting of 1235 alligators in 55

miles (22 alligators/mile). Alligator surveys conducted on the refuge, on other water conservation areas, and on the national park by biologists from many agencies from 1979 to 1987, showed fluctuating numbers of alligators related to season and water level. Alligator numbers in the canals averaged 21 alligators/mile and ranged from 8 to 101 alligators/mile. In 1998, a series of regional alligator surveys, which included the refuge, were initiated by researchers at the University of Florida (Mazzotti et al., 1999). Surveys of the refuge interior and the L-40 canal showed that the refuge had higher densities of alligators along the survey routes than any of the other Water Conservation Areas. Sixteen and nine alligators/mile were observed during surveys of the L-40 canal on the refuge, and the interior respectively (compared to a maximum of eight and two alligators/mile in other canals and marshes). Alligators of all sizes were observed along both survey routes with more larger alligators observed in the canal survey. Many pods of young of several size classes were observed along the interior survey route indicating that alligator nesting is occurring on a regular basis in the interior. In addition, alligators in and around the refuge appear to be in good condition, unlike alligators in other locations in south Florida. It is unknown if the amphibians or reptiles on the refuge have been impacted adversely by environmental conditions as they have been in other areas of south Florida.

Invertebrates

Approximately 40 species of butterflies can be found on the refuge during various times of the year (Coppen 1997). Most common are queens, soldiers, white peacocks, gulf fritillaries, julias, palmedes, and zebra butterflies (Table 20). The butterfly garden will continue to attract many species to the visitor center area. Annual butterfly surveys are being completed on the refuge as part of the North American Butterfly Count.

The Florida apple snail is an important tropical freshwater mollusk on the refuge as well as the entire Everglades. This species, as well as the exotic mystery snail and spike-topped snails are food sources for young alligators and numerous birds, including the limpkin and the Everglades snail kite (Lodge 1994). The refuge provides abundant aquatic habitat for dragonfly larvae (Lodge 1994). There are 23 species of dragonflies known to occur on the refuge. Common species include the scarlet skimmer, Halloween pennant, eastern pondhawk, and four-spotted pennant. These dragonflies feed on mosquitos, beetles, wasps, and other insects. Seven species of damselflies use the refuge habitats; among them are the duckweed firetail, Rambur's forktail, swamp spreadwing, and lilypad forktail (*Table 20*). In addition, a host of other important aquatic invertebrates such as spiders, crayfish, prawns, molluscs, snails and worms are important prey species in the marsh food web.

No formal surveys or research for apple snails, dragonflies, or damselflies, are currently being conducted on the refuge.

Fish

There are at least 46 species of temperate fresh water fish that occur regularly on the refuge including mosquitofish, topminnow, largemouth bass, gar, and bowfin (Loftus and Kushlan 1987). See Appendix K, Table 20, for a list of fish species occurring in the area.

Water level management greatly influences the range and survival of both invertebrates and fish on the refuge. Water levels can dictate vegetation, habitat structure, and vulnerability of aquatic species to predation. Structurally simple sloughs and canals are dominated by bass and other predatory fish (Loftus and Kushlan 1987). Prawns and crayfish tend to occur more often in densely vegetated wet prairies than in sloughs (Lowe 1986). Small fish and large arthropods manage to avoid large fish in sloughs but large arthropods feed on small fish in wet prairies and sawgrass stands. Prolonged high water with few droughts or drawdowns would likely result in more, larger largemouth bass, gar, and bowfin (Jordan 1996). No formal surveys regarding fish species are currently being conducted on the refuge.

Exotic Animal Species

Populations of non-indigenous aquatic animal species are increasing in Florida and this expansion, coupled with the introduction of new exotic species, poses a threat to biodiversity on par with habitat loss and degradation. Very little is known, however, about the precise nature of these threats to native species and the ecology of most of the non-indigenous aquatic animal species in Florida. Thirty-two exotic fish taxa (species, hybrids, and unidentified forms) have reproducing populations in Florida (Fuller et al., 1997). Possibly 13 species of cichlids such as the peacock cichlid, blue tilapia, and black-chinned tilapia could be found in refuge waters (Nico 1997). Giant canal shrimp can also be found at the Loxahatchee refuge, generally around water control structures.

Two recently discovered threats to the refuge and all of south Florida, an armored catfish and the swamp eel, are suspected to be causing significant disruptions in the population levels of native species. The South American armored catfish, known to achieve high population levels, feeds heavily on benthic invertebrates which are the basis for the food web in the Everglades. The swamp eel feeds voraciously on native fresh-water fish species such as sunfish and bass. It is believed that the Brazilian spike-topped apple snail is beginning to displace the native Florida apple snail, which is the primary food of the endangered Everglades snail kite (Warren 1997). Sportfish introductions to south Florida include oscars, blue tilapia, peacock cichlids, and Mayan cichlids.



Green iguana (exotic species)
USFWS Photo by S. Rinker



Banding a young Snail kite
USFWS Photo by M. Bailey

Threatened and Endangered Species

There are at least 63 imperilled species known to occur or could occur on the refuge. These species are listed as either federal or state threatened and endangered species, species of special concern, species of management concern, or listed by the Convention of International Trade in Endangered Species (*Table 22*). The Service has primary responsibility for federally listed species. However, in many cases they occupy the same or similar habitat. By managing for federally listed species, state and other listed species benefit as well.

According to Appendix K, Tables 22, 28, and 29, 15 species of wading birds such as herons, storks, and ibises nest on the refuge and are considered ecological indicators because of their wide foraging ranges and relatively specific food and habitat requirements. The breeding success of these species reflects the health of the wetland and coastal habitats of the south Florida ecosystem, the Everglades ecosystem, and need to be monitored to reflect the success of the Everglades Restudy Project.

The wading bird breeding populations of the Everglades ecosystem have declined 90 percent as a result of a 50 percent reduction in habitat and the associated reduction in fish and food items (Ogden 1994). While the refuge is a viable breeding ground for wading birds, artificially controlled hydroperiods often fail to mimic the natural system and this failure has contributed to the decline in breeding and foraging success. In May 1995, a new water schedule was instituted which more closely mimics the natural system and the effects of this schedule on nesting success are being monitored. High numbers (up to 300 per day) of wood storks have been observed foraging on the refuge interior and impoundments when the water levels are very low. Wood storks have been recorded as nesting on the refuge twice; successfully in 1990, during an extreme drought (Fish and Wildlife Service 1990; Maffai and Jelks 1991) and unsuccessfully in the drought of 1999 (Fish and Wildlife Service 1999c). The refuge has appropriate nesting habitat for wood storks and some impoundments could be managed for optimal foraging year-round. Little blue and tricolored herons, white ibis, limpkins, and snowy egrets regularly forage, roost, and nest on the refuge. While the refuge has traditionally been a productive area for snowy egrets in south Florida, nesting success has declined in recent years.

The reddish egret has been rarely observed on the refuge. While it is not unusual to see immature roseate spoonbills in the impoundments during very low water levels, they are not known to nest on the refuge. One of the rare times (1999) they were observed nesting, the effort was unsuccessful. In the 1970s, Florida sandhill cranes were observed in good numbers in the refuge interior, however, they are now rarely observed and only two nests have been recently observed, one in 1996, and another in 1999.

The Everglades snail kite has had poor nesting success on the refuge with a total of only 7 nests observed from 1976 to 1997. However in 1998, 18 Everglades snail kite nests were found and approximately 1/3 of the nests were thought to be successful (Fish and Wildlife Service 1998). The bird is mobile, moving from one watershed (or conservation area) to another as foraging conditions change. With the change in the water regulation schedule in 1995 providing better habitat for its primary prey, the apple snail, it is hoped the nomadic Everglades snail kite will increase its nesting activities at the refuge.

Bald eagles are not seen often, but a couple are observed perched in trees on or near the refuge every two or three years. Arctic peregrine falcons are routinely observed foraging and resting in the refuge interior during the fall and spring migration. American kestrels are observed wintering on the refuge, however, they are not the Southeastern Kestrel.



Nesting American alligator
USFWS Photo by S. Jewell

The American alligator appears to be doing well on the refuge. In 1999, a long term survey was initiated to determine the abundance, nesting success, and health of this species. Alligators of all sizes were observed in both survey routes, with larger alligators observed in the canal survey. Many pods of young of several size classes were observed along the interior survey route indicating that alligator nesting is occurring on a regular basis in the interior. Nests were located, opened, and the eggs measured, counted, and evaluated for viability. Tending females were captured, marked, and measurements were taken. Early indications are that alligators in and around the refuge appear to be in good condition, unlike alligators in other locations in south Florida.

Five reintroduced whooping cranes were briefly observed near the western edge of the refuge in 1998.

Occasional sightings of the Florida panther or an escaped captive mountain lion have been noted in the refuge's annual narratives and biological observations but never confirmed.

Tropical curly-grass fern was found in 1972 by Taylor Alexander on tree islands near the airboat trail, but its status is currently unknown. In 1998 two bromeliads, commonly found in the cypress swamp and on most tree islands, were listed by the State of Florida as endangered. This listing is in response to an exotic weevil which has begun devastating native bromeliad populations in south Florida. Additionally, a number of ferns has been listed in response to the rapid loss of wetlands in Florida.

Research Natural Area

The refuge features a 2,560-acre Research Natural Area, the center of which is located at 26° 34' North and 80° 22' West (*Figure 12*). This area is part of a system of Research Natural Areas located on federal lands. These areas "...preserve a representative array of all significant natural ecosystems and their inherent processes as baseline areas." (U.S. Department of Agriculture 1977.) Furthermore, these areas provide opportunities to obtain, through scientific research, "...information about natural system components, inherent processes, and comparisons with representative manipulated systems." Use of Research Natural Areas by responsible scientists is allowed as long as other areas of similar quality are available; little activity is encouraged. No baseline studies have been conducted or are currently underway on this area.

Management of the Compartments

As indicated earlier, the refuge has four sections (*Figure 14*), designated as Compartments A, B, C, and D. Each of the compartments is divided into a number of smaller impoundments. Currently Compartments A, B and C receive water from rainfall and Pump 1. This two-way pump is located at the northwest corner of Compartment A, adjacent to the L-40 canal. Each impoundment has a 36- or 48-inch culvert and water can be raised or lowered by gravity through flash board risers. Compartment D has a separate two-way pump and water structures associated with the perimeter canal.

Figure 12. Research Natural Area of A.R.M. Loxahatchee National Wildlife Refuge

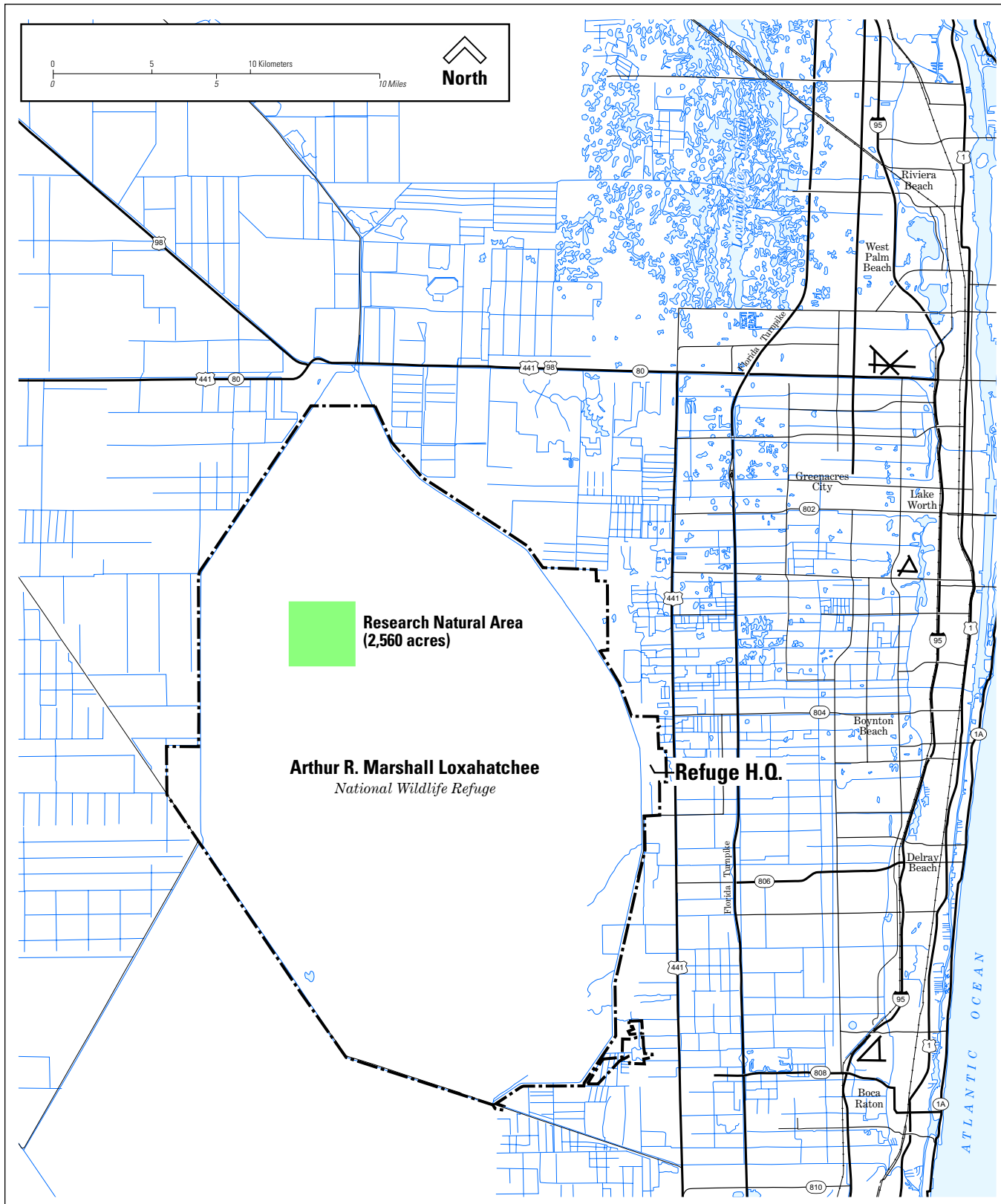
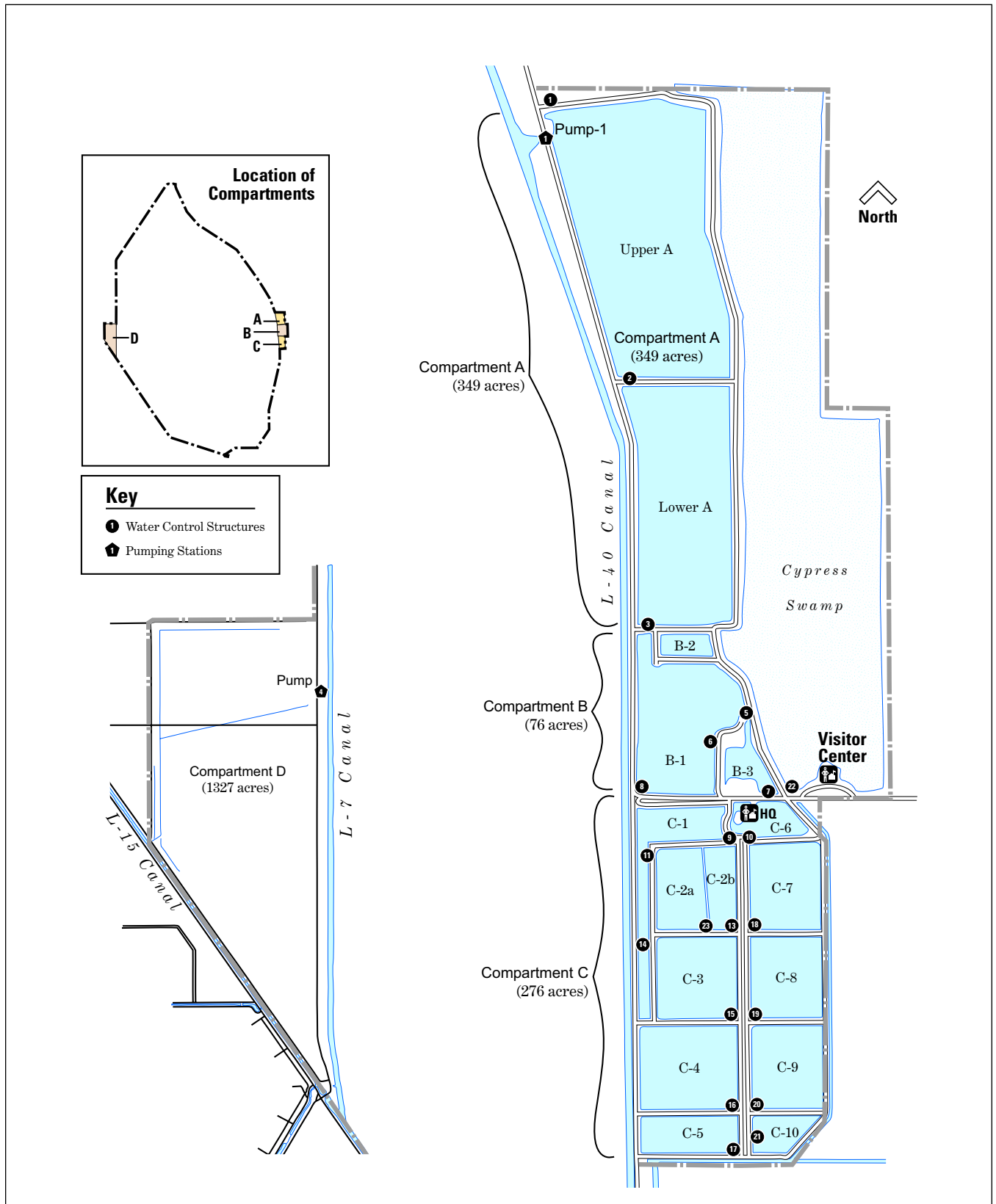


Figure 13. The location of water control structures and pumps used at A.R.M. Loxahatchee National Wildlife Refuge



Originally, Compartments A, B, and C were created to provide waterfowl habitat. In the 1960s, these compartments were managed using farming techniques. The individual impoundments were drained, dried, disced, plowed, fertilized, and replanted for the production of food (e.g., millet, rice, ryegrass) for wintering waterfowl. The use of fertilizers resulted in extensive growth of undesirable cattail, grasses, and other noxious plants. Large amounts of herbicides were used to control the unwanted vegetation.

In the 1970s, management goals of Compartment C were focused on production of apple snails as forage for the endangered Everglades snail kite. However, by 1980, farm management again was being used to control vegetation, and many impoundments were fertilized and planted with rice or millet. During this time, cattail and grasses grew extensively. In several impoundments a trail cutter was used to control the vegetation.

In the late 1980s to late 1990s, impoundment management philosophy shifted toward achieving a natural assemblage of aquatic plants, vertebrates and invertebrates, following the successional stages of the Everglades ecosystem (Fish and Wildlife Service 1992, 1998a, 1999b). In spite of these efforts, cattail and exotic grasses expanded to dominate large portions of the impoundments, due most likely to the residual effects of fertilizers applied earlier, high nutrient-laden water from the interior canal, and the effects of a closed system. The problems with invasive species in the compartments is evident as indicated below.

Compartment A (350 acres):

Portions of this compartment consist of cypress trees, sawgrass, willow, wax myrtle, and dahoon holly. However, cattail has invaded both Upper and Lower A impoundments to the point of excluding the sawgrass and overtaking the willow, myrtle, and holly.

Compartment B (76 acres):

This compartment, composed of three impoundments, B-1, B-2 and B-3, consists of spatterdock, water lily, eleocharis, and sawgrass found near the center, with abundant cattail along the edges.

Compartment C (276 acres):

This compartment is composed of eleven units (C1, 2a, 2b, and C3-10). While native plants such as sawgrass, eleocharis, spatterdock, water lily, string and spider lily, pickerelweed, and sagittaria are found in most units, cattail and exotic grasses dominate the edges and large portions of the impoundments (Fish and Wildlife Service 1995b, 1999a.). Of the units in Compartment C, only C-6 and C-7 (Marsh Trail) have been actively managed for the benefit of the visiting public for the last 18 years.

Compartment D (1327 acres):

This compartment, originally acquired to provide habitat for the listed Florida sandhill crane, is divided into two impoundments and has become overgrown with woody shrubs such as willow and myrtle and dense sawgrass. This compartment is plagued with seepage problems.

Cypress Swamp (400 acres):

The water in the cypress swamp is high in nutrients from pumped-in agricultural water, and results in dense covers of water spangles and duckweed. The understory of this pond cypress swamp is predominately fern (over nine species), herbaceous plants, dahoon holly, myrsine, red bay, buttonbush, and pond apple. This area is currently being invaded by exotic Brazilian pepper, guava, aquatic ipomoea, and Old World climbing fern.

With appropriate habitat management, the compartments have the potential of providing habitat for wildlife species found in the refuge interior. More than 25 state or federally listed species have been recorded using the compartments, including the Florida panther in the 1960s and 1980s (Fish and Wildlife Service 1996b, 1999, 1999a).

*Ecology and Role of Fire in Plant Communities***Fire Ecology:**

The refuge has a variety of vegetation types which are either dependent upon fire, susceptible to fire, or spread fire. Sawgrass marsh is extremely combustible but well adapted to fire. Beakrush and spikerush wet prairies have insufficient fuel to carry a fire under high water levels. However, when prairies are dry, a well developed algal mat can burn, smolder, and spread over long distances. Maidencane wet prairies occur in drier sites and burn almost as well as sawgrass (Wade et al., 1980). Sloughs act as natural firebreaks, since the vegetation is sparse and wet most of the year. However, if the surface sediments dry out, “muck” fires may develop in the peat. The combustion literally burns up the peat and then the slough is created when water re-floods the area. At the southern end of the refuge, where dense stands of cattail have replaced sawgrass and slough communities, extensive amounts of dead material and litter burn readily during the dry season.

Tree islands, found interspersed among the sloughs and wet prairies, will rarely carry fire during the wet season. Since sloughs and wet prairies usually contain low fuel levels, these communities will not spread fire from island to island. However, when the water table drops below ground level, tree island communities are susceptible to destructive fires. At those times, adjacent wet prairies may also be sufficiently dry to spread fire to tree islands. Melaleuca and Old World climbing fern also contribute to the spread of fire. The volatile oils in the melaleuca leaves produce intensive crown fires and “fire-brands” which increase the chance of spotting. In tree island areas, vertical growth of the climbing fern creates a “ladder effect” and produces crown fires which kill supporting trees. Pieces of fern also break off and float in the thermals causing fire to spread a half-mile or more. Tremendous spore dispersion appears to result from fire in the fern. The 1995 fire is thought to be a major contributor to the spread of the fern on the north end of the refuge. Studies need to be conducted to determine if fire does spread Old World climbing fern.

Cypress swamps are one of the primary natural barriers to the spread of wildfire (Wade et al., 1980) if water levels are high enough to provide a saturated microclimate. The 400-acre swamp provides a barrier between the compartments and adjacent farmlands. However, the invasion of climbing fern in the cypress trees has increased its susceptibility to wildfire.

Role of Fire in Everglades Plant Communities Over Time:

Lightning-caused wildfire played a continuing historical role in perpetuating the unique mosaic of plant communities in south Florida and on the refuge. This historical role is evidenced by ash layers embedded in Everglades peat (Cohen 1974), the high percentage (70 percent) of plant species which occur in communities that are maintained by fire (Robertson 1953), and the high incidence of lightning. There are more days with lightning recorded in south Florida than anywhere else in the United States (Wade et al., 1980). Many low growing plants such as sawgrass require sub-climax habitats to remain constant, and lightning fires have been a major force in interrupting plant succession in the Everglades.

During the early 1900s, Everglades ecology began to change in part because human-caused fires became much more frequent and destructive as the marsh was drained. Human-caused fires are more destructive, burn more acreage, and occur mostly in dry season (January through May) when low water levels allow tree islands and peat to be consumed. A naturally started fire usually occurs in the rainy season (May through August) from lightning strikes burning a mosaic pattern governed by existing water and patchy vegetation, and is extinguished with abundant rainfall.

During the period 1910-1960, while boundary levees were being constructed throughout south Florida to contain the Everglades, it is believed that fires were intentionally set on the refuge. These fires

destroyed many tree islands in the south end of the refuge; numerous burned-out cypress stumps on the south end give validity to this observation. Since the refuge was established in 1951, wildfires have been sporadically recorded in annual refuge narratives.

Fire Risk and Suppression:

The refuge is rated as a “low consequence” refuge based on fire occurrence, history, fuel type, severity indices, and local conditions. Fires will normally be limited in scope due to the presence of many natural firebreaks and high moisture retention in the vegetation and soils. Only during severe droughts will damaging fires likely occur. Even in these circumstances (e.g., the drought of 1981-1982), the scope of the fire may be constrained by habitat and environment and may be beneficial to wildlife. Since access to the refuge is limited to two locations, it would be relatively easy to close the refuge to public use, if necessary, to ensure public safety.

In the past, wildfire suppression has been aggressive to contain wildfire on the refuge when it is needed to protect adjacent private lands and structures. The Florida Division of Forestry is the primary agency in Florida to control wildfires, and would be the primary agency to assist with a wildfire on the refuge. Not all fires would be curtailed; rather, there are only a few circumstances when wildfires would be suppressed in the refuge interior. These include: 1) muck fires in severe drought conditions; 2) fires that produce excessive smoke on adjacent roadways or in nearby communities; and 3) fires that threaten to spread to adjacent lands. The Division of Forestry may be asked for assistance in suppressing a refuge fire, if necessary.

Socioeconomic Environment

Demographics

The population in Palm Beach County has grown 68 percent from 1980-1995 (*Table 3*). Population density in this same period has increased 60 percent. Like many counties in south Florida, Palm Beach County's population has become more diverse. Data for the period between 1980 and 1990, shows that the proportion of Caucasian and African American populations is decreasing, while the Hispanic and Asian populations are growing. The Native American population has remained a small but stable proportion. The county education levels are slightly higher than the state average. Median and per capita incomes for Palm Beach County in 1990, were much higher than the state averages (\$32,212 and \$22,135 respectively).

Table 3. Socioeconomic profile of Palm Beach County, Florida, 1980 - 1990

<i>Characteristic</i>	<i>1980</i>	<i>1990</i>
Population (number)	576,758	863,503
Population Density (pop./sq. mile)	289	433
Race/ethnicity (%)		
Caucasian	84.5%	79.3%
African American	13.4%	11.9%
Hispanic	1.6%	7.6%
Native American	0.2%	0.2%
Asian	0.3%	1.0%
Education		
% Population over 25 with HS degree	71.0%	78.8%
% Population over 25 with College degree	17.1%	22.1%
Median Family Income	\$19,817	\$38,539
Per capita Income (\$)	\$12,820	\$29,103

Poverty levels for the county have decreased slightly for both families and individuals, and are lower than the state averages (9 percent for families and 11 percent for individuals for the state). The income and poverty statistics suggest that the county residents are more affluent than residents in most other counties in Florida.

Land Use

Most of the agricultural production is in the western portion of Palm Beach County and in the Everglades Agricultural Area, which coincidentally encircles the refuge. The important agricultural products in the county include sugarcane, vegetables, melons, ornamental crops, and to a lesser extent, citrus.

As the population of Palm Beach County grew by 50 percent between 1980 and 1990, a large portion of the agricultural lands was lost to urbanization. Interestingly, the number of farms has increased within the county (15.5 percent), while the average farm size has decreased by more than 15 percent (*Table 4*). The estimated market value of land and buildings (average per acre) in 1992 was \$3,576. Due to explosive development since then, land prices have escalated.

Table 4. Agricultural summary highlights of Palm Beach County, Florida

<i>Characteristic</i>	<i>% change 1982-1992</i>	<i>1992</i>	<i>1987</i>	<i>1982</i>
Farms (number)	15.5%	924	975	800
Land in farms (acres)	-4.4%	637,934	659,438	667,817
Average size of farm (acres)	-17.4%	690	676	835
Estimated market value of property (land and buildings average \$/acre)	47.5%	\$3,576	\$3,233	\$2,424

Recreation Use

National and Regional Context:

The 1996 National Survey of Fishing, Hunting, and Wildlife-Associated Recreation indicated that in Florida, there were 2.9 million participants in fishing, 29,000 participants in hunting, 1.8 million wildlife watchers, with 3.6 million participants completing this survey (many respondents participated in more than one activity). Since 1991, Florida statistical trends indicate about a 30 percent decline in participation in hunting and nonconsumptive wildlife watching, while participation in fishing has remained about the same.

In the 4-county (Palm Beach, Martin, St. Lucie, Indian River) state planning region, where the refuge is located, of 62 million participants in outdoor recreation (1992), 47 percent were tourists, 39 percent were residents of the region, and 14 percent were Florida residents located outside of the region. The most popular outdoor recreational activities were saltwater beach activities, bicycle riding, fishing, hiking, picnicking, and nature study. The activities with the highest projected facility needs for the year 2000, include fresh water and saltwater non-boat fishing, hiking, bicycling, and horseback riding trails.

Table 5. Highest Recreational Use at A.R.M. Loxahatchee National Wildlife Refuge, FY98

<i>Type of Use</i>	<i>Estimates</i>
Total Visitors	110,642
Visitor Center	64,930
Nature Trails - Foot Trails	91,147
Fishing	20,346

Refuge Recreation Use:

The visitation to the refuge was estimated at 110,000 visitors per year since 1994. Visitation varies by season. Approximately 17,000 visits occur monthly during February-March, and 4,000-6,000 per month in September-October. Of the total visitation, interpretation, nature observation, and fishing comprise most of the recreation uses on the refuge. In FY 1998, nearly 65,000 persons visited the visitor center and/or nearby boardwalk, about 91,000 walked the nature trails, 20,346 fished and approximately 264 people hunted on the refuge (*Table 5*).

Access

The Headquarters Area is located on Lee Road, which originates from State Highway 441. This area provides refuge administration, interpretation/education, and public access (*Figure 14*). Visitors will pass an entrance fee station which is staffed during peak hours and is run on the honor system the remaining time.

The Headquarters Area is located in and around Compartment C (*Figure 14*), one of 4 compartments (A- D). Compartment C contains an observation tower, bridge, and 10 impoundments, approximately 25 acres each, which are contained by 6 miles of levees. A 1/4-mile interpretive boardwalk circles through the Cypress Swamp. Located in the area are three boat ramps, an observation platform, and a concrete fishing platform (both wheelchair accessible).

The interior of the refuge is currently allocated into three management zones: Closed to Public Use; Open to Public Use except no waterfowl hunting; and Open to Public Use, waterfowl hunting by permit only (*Figure 14*).

In addition to the Headquarters Area, visitors can access facilities at the Hillsboro Recreation Area. This area, located in the southern part of the refuge, contains a gravel parking lot and 4 boat ramps. Only 2 ramps are usable at the present time.

Another traditional entrance to the refuge, 20-Mile Bend Recreational Area, located at the northern end of the refuge, has been closed for development of the Everglades Stormwater Treatment Areas.

Wildlife Observation and Photography

Wildlife observation and photography, notably of birds and alligators, occur at any location where access is allowed. Land-based observation occurs along the Cypress Swamp Boardwalk, Marsh Trail (C-7 Impoundment) throughout Compartment C, and along the perimeter levee. As indicated above, the C-7 Impoundment can provide some special opportunities to observe wildlife. In the refuge interior, water-based observation from boats or canoes occurs along the Everglades Canoe Trail and in the Public Use Area, located in the southeastern area of the refuge.

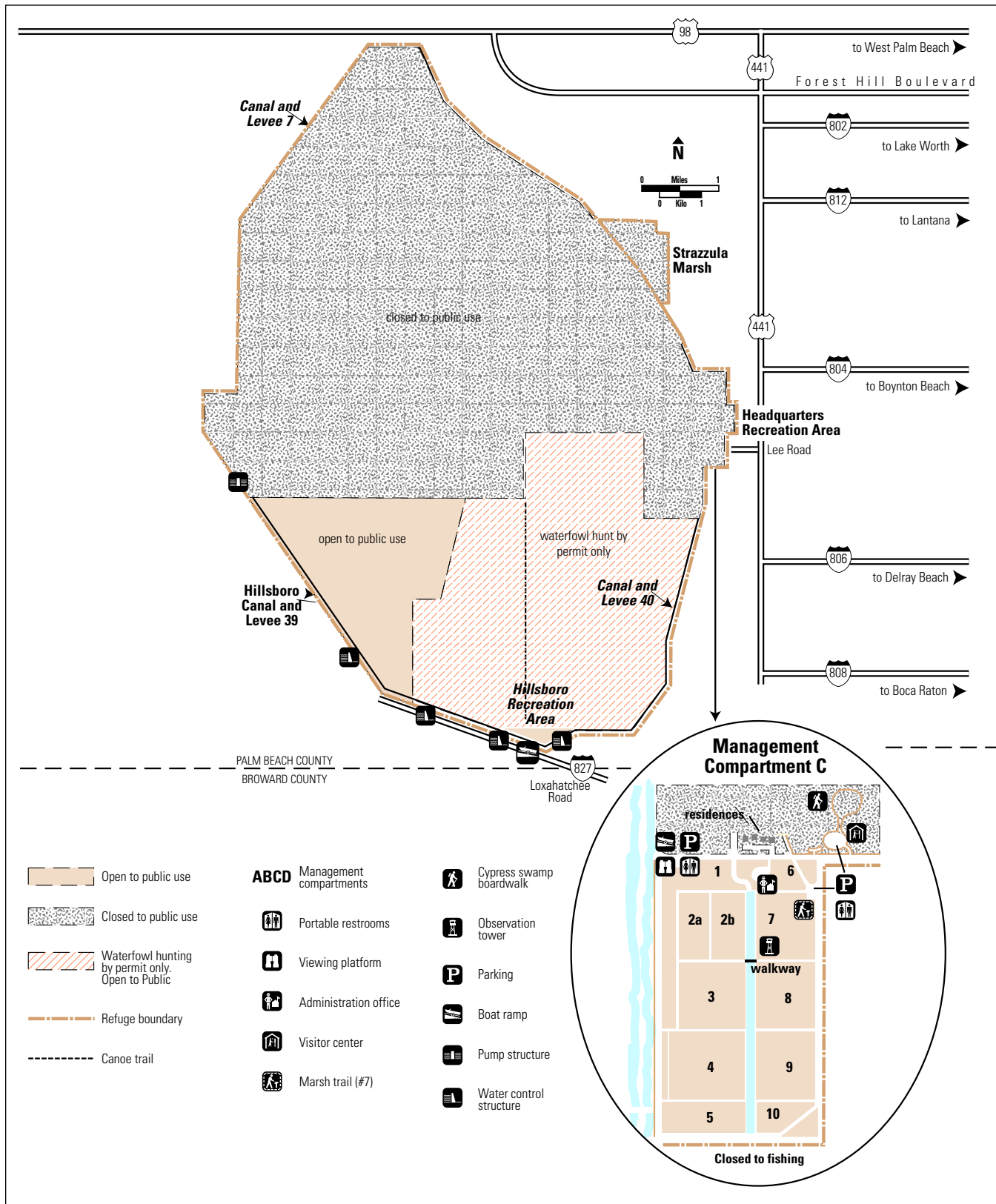
Interpretive Programs

The visitor center provides exhibits, seasonal talks, and slide programs. Field guides, nature books, and other materials can be purchased here. The Loxahatchee Natural History Association produces a visitor guide to the refuge and holds an annual art contest and photo contest. Guided tours, audiovisual and guest lecture programs are offered throughout the year.

Walking/Hiking/Bicycling

Walking and hiking is available in the following areas: the Cypress Swamp Boardwalk (0.4 mile); Marsh Trail (0.8 mile); the perimeter of Compartment C (6 miles); and the levee between the ACME 2 Station (northern edge of Strazzulla Marsh) to the Hillsboro Recreation Area (12 miles), and up to the S-6 water structure at Compartment D (*Figure 14*). Bicycling is allowed on the perimeter levee from the Headquarters Area to Hillsboro.

Figure 14. Current Location of Compartments A,B,C,and D, Headquarters Area, Strazzulla Marsh and Hillsboro Recreation Area at A.R.M. Loxahatchee National Wildlife Refuge





Canoe trail
USFWS Photo by B. Thomas

Fishing

Boat-based sport fishing occurs in the perimeter canals and open public use areas, and bank fishing occurs at the Hillsboro Recreation Area and the headquarters canal area (*Figure 14*). The primary species caught include large mouth bass, redear sunfish, bluegill, warmouth sunfish, and tilapia.

Canoeing/Kayaking/Boating

Canoeing, kayaking, and motorboating are permitted in the Public Use Area and in the 57-mile perimeter canal, providing sufficient water is available. In some parts of the canal, weed growth may prevent boat or canoe passage. Canoeing and kayaking is also available on the 5.5 mile canoe trail, located near the refuge headquarters and parking area (*Figure 14*). One platform toilet is located along the trail.

The majority of the boating occurs along the L-39 canal, located on the southwest perimeter. Boat access is available at two of the four boat ramps located at the Hillsboro Recreation Area and three ramps at the Headquarters Area.

Hunting

Waterfowl hunting is permissible in a designated area in the southeast corner of the refuge (*Figure 14*). A refuge permit, federal duck stamp, and state hunting license are required. The refuge operates special restrictions over and above state regulations during the November to January hunt. During 1995-1997, less than 1 percent of refuge visitors participated in hunting activities.

Recreation Economics:

A 1995 study, using the National Park Service's Money Generation Model, shows the extent of the refuge's contribution to the local economy (*Table 6*). This model estimated that the refuge produces 12,533 visitor days of use, and this level of visitation resulted in more than \$350,000 in direct sales and nearly \$700,000 in total economic benefits. The refuge was also estimated to produce \$41,124 in increased sales tax revenues and that 28 jobs were created in the community by refuge-related tourism.

Table 6. Economic impacts of A.R.M. Loxahatchee National Wildlife Refuge, 1995. (Correia 1995)

<i>Impact Factors</i>	<i>Amount</i>
Visitor days	12,553
Estimated direct sales to visitors	\$351,484
Estimated sales benefits from tourists	\$685,394
Increased sales tax revenues	\$41,124
Estimated new jobs created by refuge-related tourism	28

Data concerning average recreational expenditures per visitor day by specific activities for the Southeast Region shows that non-consumptive activities (such as birdwatching, photography, and hiking) and fresh water fishing, which are major refuge recreational activities, contribute to Palm Beach County's economy (*Table 7*). Each visitor day of non-consumptive activities, on average, produces about \$12 in spending for local residents, and nearly \$36 spending for non-residents (1992 dollars). Fresh water fishing produced significantly higher spending averages for non-residents (\$44), but less for residents (\$11). Refuge visitation and the accompanying

spending by visitors undoubtedly contribute to the economy of both Palm Beach and Broward counties.

Table 7. Southeast Region Recreation Expenditures *per person, per day by activity (1992 dollars) (Laughland and Caudill 1997)*

<i>Sector</i>	<i>Non-consumptive</i>		<i>Fresh-water Fishing</i>	
	<i>Resident</i>	<i>Non-resident</i>	<i>Resident</i>	<i>Non-resident</i>
<i>Lodging</i>	\$0.0	\$6.75	\$0.0	\$7.78
<i>Food/drink</i>	\$6.56	\$15.08	\$5.62	\$17.34
<i>Transportation</i>	\$5.14	\$13.11	\$3.71	\$6.30
<i>Other</i>	\$0.38	\$0.63	\$1.61	\$3.17
<i>Total</i>	\$12.08	\$35.57	\$10.94	\$44.59

Cultural Environment

Prehistoric Background

Archaeologists suspect that prehistoric occupation did not occur on the refuge because of little dry land on which to live. Even tree islands, which are thought to have formed recently, would have been unsuitable for prehistoric occupation (Griffin et al., 1979). Three sites show evidence of the Glades tradition within close proximity to the refuge (Griffin et al., 1979). The sites mentioned include the Cagles Hammock site (Mower and Williams 1974), the Markham Park site (Williams and Mowers 1977), and the Peace Camp site (Mowers and Williams 1972).

Belle Glade (Okeechobee) Area

Griffin et al., (1979) have hypothesized that the refuge may have been used by the Belle Glade People to travel east toward the Atlantic. Once there, the Belle Glade People could have traded with the groups there, or harvested the marine goods recovered at Fort Center (Griffin et al., 1979).

The closest Belle Glade site to the refuge (according to Griffin et al., 1979) is the Boynton Mound Complex located within ½ mile of the eastern boundary.

Historic Period

By the time European explorers stepped foot on the Florida peninsula, there were five tribal groups associated with the east coast of Florida. These groups were the Timicua to the North, the Ais, the Guacata, the Jeaga, and the Tequesta to the south. All tribes were known to collect shellfish and other marine and aquatic resources, which resulted in large shell and bone middens near the villages (Andrews and Andrews 1985). There is evidence that these middens/mounds were used as safe-havens of dry land when coastal flooding occurred (Andrews and Andrews 1985).

Tribal groups most associated with the refuge area were the Guacata, the Jeaga and the Tequesta (Griffin et al., 1979). It appears that the Guacata occupied a territory in a band north of the refuge which included the eastern shore of Lake Okeechobee and the coast near St. Lucie. Other groups such as the Jeaga and perhaps even the Tequesta would be located south of what is now the refuge.

By the 1800s, Native Americans from Georgia, Alabama, and South Carolina began filtering down into the Florida peninsula. These people became more cohesive through time as they fought together against the encroaching Europeans in the Second Seminole War of 1835-1842 (Neill 1956). The war's end could be nothing but a loss for the Seminoles as they were forcibly moved west. Those that chose to remain made their way into the Everglades inhabiting a land that the newer Americans did not seem to want (Griffin et al., 1979).

With improved transportation, more settlers began to move into the area. Small communities, most of which were short lived, sprang up near the refuge. These consisted of Belle Glade c. 1913; Glade Crest c. 1914, on the Hillsboro Canal; Shawano c. 1924, on the Hillsboro Canal; 20 Mile Bend at the juncture of the Hillsboro and West Palm Beach Canals, Gladeview on Hillsboro Canal, and Loxahatchee c. 1913, on West Palm Beach Canal (Will 1964:180; Will 1968:33) (Griffin et al., 1979). The new settlements, with associated road construction, managed to bypass the refuge due to the inhospitable environment.



*Aerial view of refuge canoe trail
USFWS Photo by S. Jewell*

IV. Management Direction

Introduction

Described below are a vision statement, goals, and the plan for managing the refuge over the next 15 years. Contained in the plan are the goals, objectives, and strategies for achieving the refuge vision.

The planning team evaluated four alternatives for managing the refuge, and chose the Ecosystem Emphasis alternative as the preferred alternative. The other alternatives evaluated were Maintain Current Management, Biological Emphasis, and Public Use Emphasis. These alternatives are described in the Alternatives section of Appendix A.

In essence, the preferred alternative will result in increased invasive exotic plant eradication and control, improved water quality, delivery and timing, increased protection of trust species, protection of migratory songbird stopover sites, restoration of wetland impoundments, enhanced resident wildlife populations, and improved long-term opportunities for appropriate and compatible wildlife-dependent recreation, environmental education and interpretation.

A common thread through this plan is that wildlife conservation assumes first priority in refuge management. Public uses are allowed if they are appropriate and compatible with wildlife and habitat conservation. Specifically, wildlife-dependent recreation uses (hunting, fishing, wildlife observation, wildlife photography, and environmental education and interpretation) will be emphasized.

Refuge Vision

The planning team, in consideration of input through public meetings and draft reviews of this plan, has developed the following vision for the A.R.M. Loxahatchee National Wildlife Refuge to guide its present and future management direction:

To serve as an outstanding showcase for ecosystem management that restores, protects and enhances a portion of the unique northern Everglades biological community. This public asset provides for the enjoyment and enhanced quality of life for present and future generations.

Refuge Goals

The following four goals were developed in keeping with refuge vision and purpose:

- Restore and conserve the natural diversity, abundance, and ecological function of refuge flora and fauna.
- Conserve natural and cultural resources through partnerships, protection, and land acquisition from willing sellers.
- Develop and implement appropriate and compatible wildlife-dependent recreation and environmental education and interpretation programs that lead to enjoyable experiences and greater understanding of the Everglades and south Florida ecosystems.
- Continue a partnership with the South Florida Water Management District, including renewal of the license agreement for Water Conservation Area 1. Continue the development of an effective and productive staff to achieve the vision, goals, and objectives of this plan.

Management Plan*Summary Statement*

This management plan was derived from Alternative 2 and amended to reflect the comments from the public, non-governmental organizations' and agencies' review of the draft plan. The refuge will be managed using an ecosystem management approach to maintain natural processes or to mimic those processes such as fire and water regimes. In doing so, the refuge will be managed to meet the needs of the resources and allow greater public access for hunting, fishing, wildlife observation, wildlife photography, and environmental education and interpretation. Oral comments made during public meetings and written comments conveyed both a desire for increased public access and recreation and a desire to preserve the solitude and natural environment of the refuge. The decisions to allow or to prohibit certain uses were dependent upon whether the proposed uses would have an adverse effect on the natural resources of the refuge (see Table 17; Appendix D; and Appendix J) and upon the professional judgement of the refuge staff and planning team.

The management plan outlines how wildlife and habitats will be enhanced by the refuge over the next 15 years. The goals, objectives, and strategies are a recognition that the refuge is a portion of the much larger Everglades ecosystem. The actions considered and taken in implementing this plan will affect the remaining Everglades ecosystem south of the refuge, the natural areas southwest of the refuge, and nearby municipalities and landowners.

A crucial element of this plan is controlling exotic and invasive plants and pursuing funding to eliminate these refuge threats. Also, appropriate water quantity, timing, delivery, and high quality water are critical to achieve refuge objectives and those of the Everglades ecosystem, of which the refuge is a part. Water management, the movement of water into and out of the refuge with appropriate timing and amounts relative to habitat and wildlife needs, will rely upon developing progressive partnerships with the South Florida Water Management District and the U.S. Army Corps of Engineers. This plan also enhances biological and research programs including extensive inventorying, Geographic Information System mapping, and monitoring of the wildlife and habitat resources at the refuge. Prescribed fire will be used as an important tool for managing wildlife habitat. All of the compartments (2,550 acres) will be actively managed to enhance wildlife habitat. Restoration of Compartment A to cypress swamp will begin with cypress planting and relevant levee removal.

The environmental education and outreach program will be enhanced to showcase the northern Everglades ecology and human influence on the southeast Florida ecosystem. A wide range of partnering opportunities will be actively pursued and fostered to share in the protection of natural and cultural resources. A visitor contact station with interpretive exhibits and a concession will be developed at the Hillsboro Area to enhance

appropriate and compatible wildlife-dependent recreation. This plan will increase hunting accessibility by increasing the effective hunting acreage and the number of huntable species. The previously closed Strazzulla Marsh will be opened to the public on a limited basis and new facilities will be developed to include an interpretive trail, a boardwalk, an observation tower and possibly a poleboat trail. Parking access will be potentially developed through partnership with the Village of Wellington and the ACME Drainage District. Facilities at the Headquarters Area will be expanded or upgraded.

Goals, Objectives, and Strategies

The goals, objectives, and strategies presented below are the Service's response to the issues and concerns expressed by the planning team, by the public at open meetings (two), and by comments submitted by the public. Those issues addressed, but not accepted, are discussed in Appendix J. The goals, objectives, and strategies are presented in hierarchical format. Following each goal is a list of objectives, and under each objective is a listing of strategies which are indicated as bulleted items. The goals are equally important in the plan. The Plan Implementation section shows the support projects for the goals in priority order.

These objectives and strategies reflect the Service's commitment to achieve the mandates of the National Wildlife Refuge System Improvement Act of 1997, and its stated mission, of the National Wildlife Refuge System, the Endangered Species Act, the Comprehensive Everglades Restoration Plan (formerly the Restudy). The purpose gives guidance to the vision and goals for the refuge. With adequate staffing and funding, outlined in the Plan Implementation section, the Service intends to accomplish these goals, objectives, and strategies during the next 15 years.

Goal 1. Wildlife Habitat and Population Management

Restore and conserve the natural diversity, abundance, and ecological function of refuge flora and fauna.

Discussion:

Water is the lifeblood of the Everglades and every effort will be made to monitor water quantity, timing and delivery as well as water quality. Water hydropattern management includes regulating the amount of water released into or taken out of the refuge, the timing of water delivery or removal, length of time water is retained and the seasonal importance of water in the refuge and surrounding areas. The refuge will rely upon developing progressive partnerships with the South Florida Water Management District and the U.S. Army Corps of Engineers relating to water delivery, timing, and amount. Also, tests will be conducted for pesticides, fertilizers, and elemental contaminants in waters and underlying soils of the compartments, cypress swamp, and Strazzulla Marsh, as well as below the major inflow water structures and other pertinent locations. Exotic and invasive plants are a major threat to the whole Everglades ecosystem and especially to the refuge. An Integrated Pest Management Plan will be developed to attack this extensive problem. Approximately 71,000 acres infested with varying densities of melaleuca and 25,000 acres infested with Old World climbing fern will be reduced to a maintenance control level. The Everglades ecosystem evolved under the influences of fire and the refuge will implement a fire management program that enhances native plant communities. Prescribed fire will also be used to remove treated, dead, exotic and invasive plant biomass and to control new exotic and invasive plant growth in treated areas. All of the compartments (2,550 acres) will be actively managed to enhance wildlife habitat. To be enhanced are the biological and research programs, including extensive inventorying, Geographic Information System mapping, and monitoring of wildlife and habitat. The emphasis of the biological program will be to protect, maintain, and enhance wildlife populations, native habitats and vegetative communities on the refuge. A comprehensive step-down management plan will be developed to detail these methods.

Objectives:

1. Continue to partner with the South Florida Water Management District and the Army Corps of Engineers to restore and maintain healthy water regimes and appropriate hydropatterns for 143,238 acres (Water Conservation Area 1) of the refuge as part of the northern Everglades.
 - Evaluate and monitor hydrologic conditions on the refuge.
 - Review and improve the existing hydrologic model for the refuge to more closely predict wildlife population and vegetative community responses to changes in water levels and water delivery.
 - Assess the impacts of the previous, current, and future water regulation schedules regarding quality, quantity, delivery, and timing of water on native and exotic and invasive species and habitats.
2. Expand water quality monitoring to include pesticides, fertilizers, and elemental contaminant levels in the cypress swamp, compartments, Strazzulla Marsh, below the inflow water structures, and other pertinent locations.
 - Work with state and federal agencies, universities, and other parties associated with the Comprehensive Everglades Restoration Plan.
 - Continue to monitor nutrient levels and add new monitoring sites at all water inflows of the refuge not currently being monitored.
 - Improve the water quality in the cypress swamp.
 - Develop a Water Quality Monitoring Plan by 2002.
3. Reduce exotic melaleuca and Old World climbing fern to a maintenance control level in 15 years and restore treated areas with native plants as needed.
 - Aggressively pursue funding for the removal of exotic plants.
 - Develop an Integrated Pest Management Plan by 2002.
 - Inventory and map the distributions of invasive and exotic plant species, and using Geographic Information Systems, map all exotic and treatment areas.
 - Develop eradication and control programs for invasive and exotic species.
 - Develop restoration programs for native habitats.
 - Review and update the existing Melaleuca Management Plan by 2002.
 - Develop a complete Lygodium Management Plan in conjunction with other natural resource agencies and researchers by 2002.
 - Foster partnerships with organizations and agencies addressing common issues, including those that are developing bio-control agents.
4. Monitor, control, or eradicate exotic or invasive animal threats.
 - Develop an Integrated Pest Management Plan by 2002.
 - Inventory and map the distributions of invasive and exotic animal species, and using Geographic Information Systems, map all exotic and treatment areas.
 - Develop control programs for invasive and exotic animal species.
 - Develop a complete Exotic Animal Management Plan by 2002.
 - Aggressively pursue funding for the removal of exotic animals.
 - Foster partnerships with organizations and agencies addressing common issues, including those that are developing bio-control agents.

5. Implement a fire management program to simulate the historical Everglades ecosystem fire regime where appropriate, enhancing native plants and deterring invasive and exotic plant spread by January 2004.
 - Revise the Fire Management Plan to manage appropriate refuge habitats by 2001.
 - Update the Fire Management Plan at 5-year intervals.
 - Monitor and evaluate prescribed burning effects to assist in determining future burn plans.
 - Partner with other natural resource agencies and organizations to implement burn prescriptions.
6. Inventory, map, and monitor wildlife and habitats of the northern Everglades. Compile, collect, and analyze these data to guide refuge management and to contribute to Everglades restoration evaluations.
 - Compile historic data and establish a continuous data collection and analysis effort.
 - Develop computerized databases to facilitate data storage and retrieval, including Geographic Information System capabilities. These databases will be compatible with Service standards.
 - Through inventory and monitoring, establish trends of sensitive habitats, trust species, focal species and biological indicators (Everglades snail kites, wading birds, and alligators) in conjunction with the Science Subgroup on Everglades Restoration.
 - To promote biological diversity on the refuge, develop a program to monitor tree islands so that the effects of management can be assessed.
 - Formulate a Biological Inventory/Monitoring Plan by 2003.
7. Manage the compartments, cypress swamp, and Strazzulla Marsh to enhance habitat for trust species such as neotropical migrants, shorebirds, waterfowl, wading birds, and alligators.
 - Ensure that equipment needs are met to fulfill this objective, and develop partnerships with local landowners and agencies.
 - Increase partnerships with the Everglades Agricultural Area landowners and other surrounding landowners.
 - Develop a Moist Soil/Water Management Plan for the compartments, cypress swamp, and Strazzulla Marsh by 2002.
 - Restore Compartment A to cypress swamp.
8. Manage and maintain diverse native habitats and viable wildlife populations consistent with sound biological principles and other objectives of this plan.
 - Identify habitat needs through data collection and analyses.
 - Maintain or enhance the habitat of trust species such as threatened and endangered species, species of concern, and migratory birds.
 - Enhance trust species nesting success by providing cover and stop-over sites for migratory birds by reducing human disturbance, and by providing or creating nesting, roosting, and foraging habitat.
 - Support and implement listed species recovery plans.
 - Provide data and analysis to contribute to updating the Multi-Species Recovery Plan for south Florida.
 - Map native plant communities and incorporate data into a Geographic Information System.
 - Monitor changes and trends in wildlife, fish, and habitat.
 - Support Partners-In-Flight initiatives with habitat management, outreach, and staff networking.
 - Support Partners In Amphibian and Reptile Conservation with habitat management, outreach, and staff networking.
 - Formulate a Biological Inventory/Monitoring Plan by 2003.

Goal 2. Resource Protection

Conserve natural and cultural resources through partnerships, protection, and land acquisition from willing sellers.

Discussion:

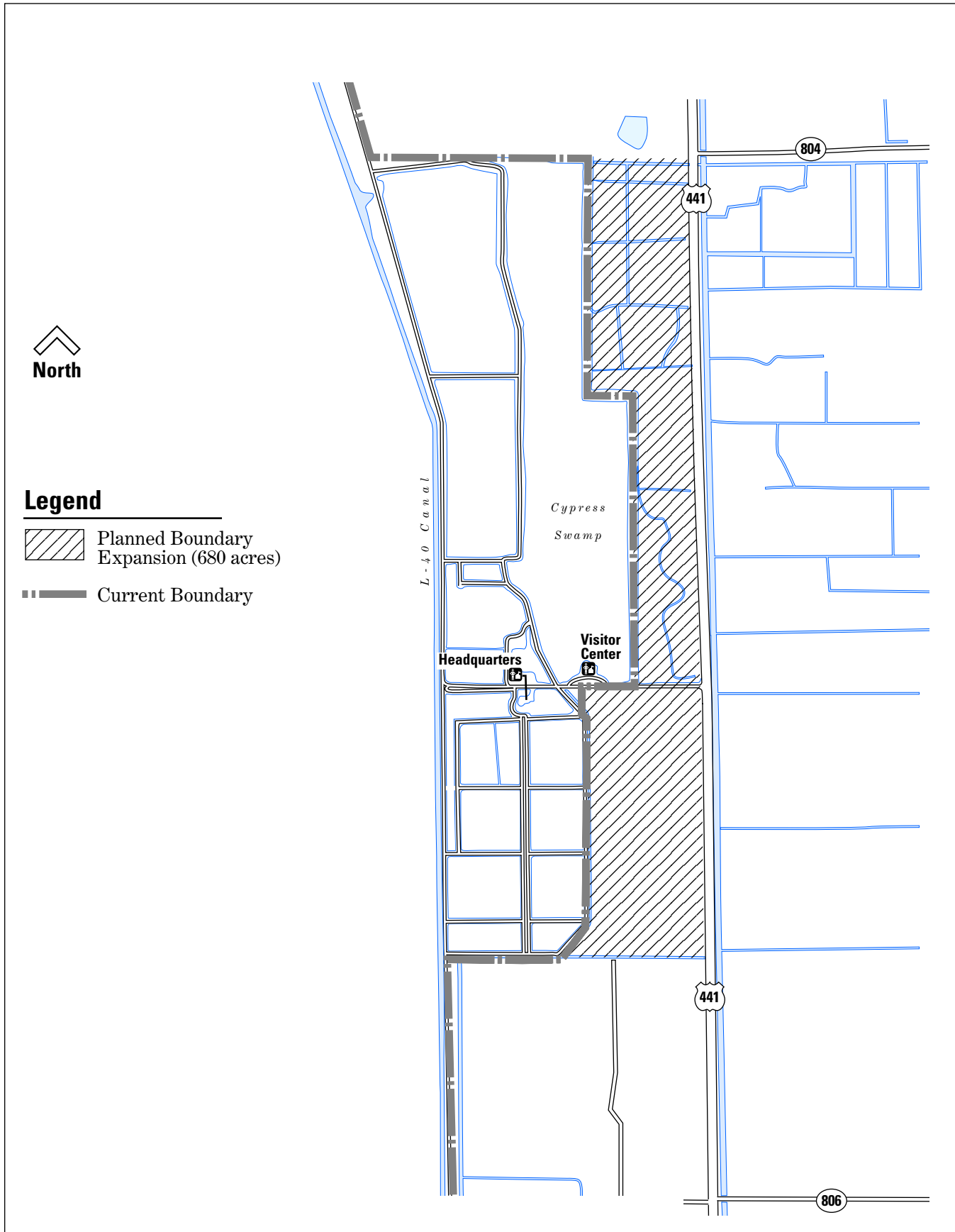
Developing and cultivating active partnerships with a wide-ranging group of interested parties is imperative to fully protect and manage refuge resources and to achieve the vision of this plan. The refuge is currently threatened by impending business and residential development on the eastern refuge border. The refuge will realign the acquisition boundary to include the lands immediately east of the Headquarters Area (approximately 680 acres, see Figure 12). The refuge recognizes the lands east of the refuge up to U.S. Highway 441/State Road 7 as “Areas of Concern” or “Buffer Lands.” A wide range of partnering opportunities will be actively pursued and fostered to protect natural and cultural resources.

Objectives:

1. Protect water resources and develop partnerships to ensure an appropriate water regulation schedule (quantity, delivery, and timing), as well as ensuring proper water quality for the benefit of wildlife and habitats of the northern Everglades.
 - Partner with Corps of Engineers, Florida Department of Environmental Protection, South Florida Water Management District, local drainage districts and universities to ensure Class III water quality on the refuge.
 - Partner with Corps of Engineers and South Florida Water Management District to implement the water schedule and be in contact on a frequent basis or better.
2. Protect other natural biological resources on or near the refuge by encouraging communication and developing partnerships with interest groups, landowners, and with the law enforcement division of resource agencies.
 - Work with adjacent landowners to establish an exotic free “buffer zone” and wildlife corridors.
 - Develop partnerships for research, control, and monitoring of exotic and invasive species with entities such as the Florida Exotic Pest Plant Council, Southeast Florida Invasive Plant Working Group and the South Florida Water Management District.
 - Develop new and continue existing partnerships for research and monitoring of biological resources with universities, conservation organizations (e.g., Ducks Unlimited, Waterfowl USA, Partners-In-Flight), and agencies (e.g., South Florida Water Management District, Florida Department of Environmental Protection, and Florida Fish and Wildlife Conservation Commission).
3. Realign the refuge acquisition boundary “Area of Concern” and recognize “Buffer Lands” along the eastern side of the refuge.
 - The refuge recognizes the lands along the east side of U.S. Highway 441/State Road 7 and in front of the refuge headquarters entrance as a new acquisition boundary (*Figure 15*).
 - The refuge considers the land east of U.S. Highway 441/State Road 7 and to the south of the refuge to be a potential buffer zone (*Figure 2*).
 - Develop collaborative relationships with federal, state, and county land offices, agencies, organizations, and landowners to ensure the “Areas of Concern” remain as agricultural or natural lands.
 - Work with federal, state, and county land offices to protect approximately 680 acres directly in front of the Headquarters Area and restore them to cypress swamp or wetlands.

4. Protect species from exposure to contaminants by following applicable regulations.
 - Implement Integrated Pest Management Plan
 - Comply with current contaminant response plans.
 - Continue partnerships with agencies testing for mercury levels in fish.
 - Through education and outreach, encourage the use of integrated pest management by Everglades Agricultural Area landowners and other surrounding landowners.
5. Protect refuge resources (147,392 acres), facilities associated with three visitor use areas, and the visiting public through appropriate law enforcement.
 - Refuge law enforcement officers will keep informed of refuge programs and will be engaged in educational contacts with the public.
 - Update and enhance the refuge's Law Enforcement Plan by 2002 and establish partnerships with other law enforcement agencies.
6. Develop and implement a cultural resource protection plan in accordance with federal and state historic preservation legislation.
 - Pursue funding for a comprehensive archaeological survey of the refuge.
 - Consult with the State Historic Preservation Office and the Keeper's Office to determine eligibility of each identified site for listing on the National Register of Historic Places.
 - Using survey information, develop a Geographic Information System layer for the refuge's archaeological and historic sites by 2003.
 - Develop a Cultural Resource Protection Plan by 2003.
7. Diminish the looting and vandalism of known or newly discovered archaeological sites.
 - Each refuge law enforcement officer will complete the Archaeological Resources Protection Act training course within 2 years of arriving at the refuge.
 - Pertinent refuge staff will complete the Section 106/Cultural Resources for Managers training course within 2 years of arriving at the refuge.
 - Work with the State Historic Preservation Office to ensure confidentiality of cultural resource data within the refuge and the State of Florida.
8. Encourage partnerships to protect cultural resources.
 - Work with the pertinent federal and state agencies, the State Historic Preservation Office, professional archaeologists, Native American communities, and the public.
 - Develop Memorandums of Understanding with pertinent federal and state agencies (e.g., the Florida Department of Environmental Protection) to enhance law enforcement of the Archaeological Resources Protection Act, the Native American Grave Protection and Repatriation Act, and applicable portions of Section 50, Code of Federal Regulations.
 - Facilitate investigations of the Archaeological Resources Protection Act violations and illegal artifact collections on the refuge.
 - Through the efforts of the Regional Archaeologist, obtain information on and input into the management of significant cultural and sacred sites from Miccosukee and Seminole Tribes.

Figure 15. Proposed boundary expansion near the Headquarters of A.R.M. Loxahatchee National Wildlife Refuge



Goal 3. Public Use

Develop and implement appropriate and compatible wildlife-dependent environmental education and interpretation programs and recreation opportunities that lead to enjoyable experiences and greater understanding of the Everglades and south Florida ecosystems.

Discussion:

As identified in the National Wildlife Refuge System Improvement Act, there are six high priority wildlife-dependent recreation uses. These are hunting, fishing, wildlife observation, wildlife photography, and environmental education and interpretation. Fundamental to the provision of these uses are viable and diverse fish and wildlife populations and the habitats upon which they depend. These priority uses, along with all other uses, must be appropriate and compatible with the refuge purposes and the mission of the National Wildlife Refuge System. The compatibility of refuge uses is addressed in Appendix D.

To ensure a quality wildlife-dependent recreational experience, while achieving a “wildlife first” mandate, the number of refuge users and conflicts among users may be limited by (1) permitted uses; (2) designating trails, levees, and sites for specific kinds of wildlife-dependent recreation use; and (3) permitting uses at certain times of the year.

There are a number of situations where future refuge closures or restrictions may be warranted. Examples of these situations include, but are not limited to, specific designated use areas; the protection of endangered species; protection of colonial bird nesting colonies or roost sites; establishment of sanctuary areas for waterfowl; restriction of hunting to certain days of the week; closing a hunt season due to population decline; establishment of hunter quota systems to provide for a high quality hunting experience or to achieve specific wildlife population objectives; minimizing conflicts with other refuge management or public use programs; safety considerations; and/or inadequate funds or staff to administer the activities.

Objectives:

1. Expand appropriate and compatible wildlife-dependent recreational opportunities at the Headquarters Area (*Figure 16*).
 - Update the existing Public Use Management Plan by 2002, and host appropriate events such as Everglades Day, International Migratory Bird Day, National Wildlife Refuge Week, and seasonal “Calendar of Events” programming.
 - Repair existing trails at the Headquarters Area and meet or exceed the Americans with Disabilities Act code.
 - Enhance the cypress swamp boardwalk by constructing a tree canopy observation tower.
 - Rehabilitate and elevate the existing observation platform at the boat launch area.
 - Rebuild the boardwalk into the C-8 Impoundment and build a photo blind by 2001 through partnerships with our various refuge support groups and other volunteers.
 - Improve visitor services such as enhanced informational and educational signage and additional benches throughout Compartment C trails
 - Extend the existing canoe trail at the Headquarters Area and include one or two overnight camping platforms.
2. Provide public access to the Strazzulla Marsh (*Figure 17*).
 - Develop two short boardwalks, an observation tower, photo blinds, and interpretive signage.
 - Create a poleboat trail in the refuge interior, with access from Strazzulla Marsh (depending on water quality improvement in the perimeter canal.)

Figure 16. Expanded public use opportunities at the Headquarters Area, A.R.M. Loxahatchee National Wildlife Refuge.

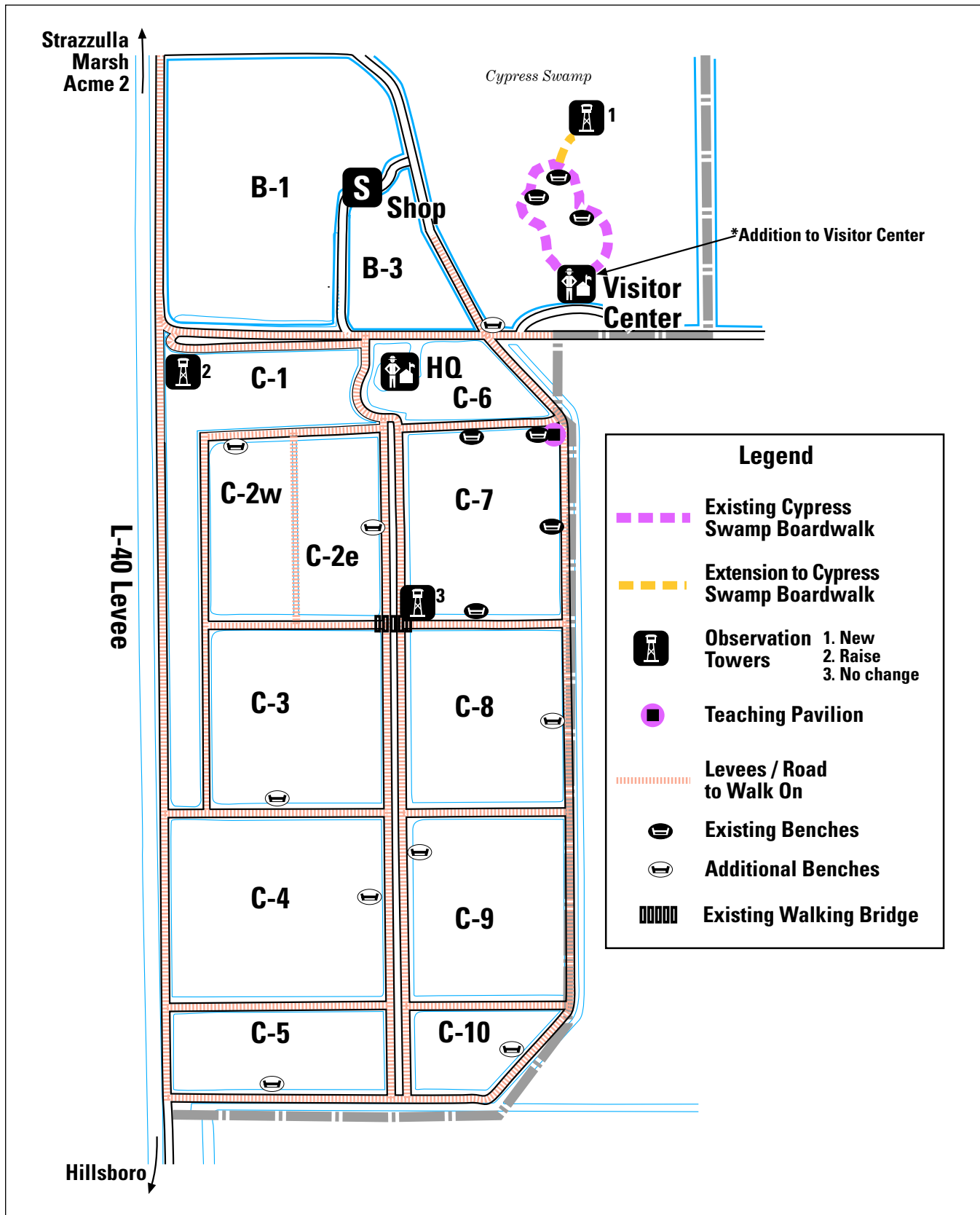
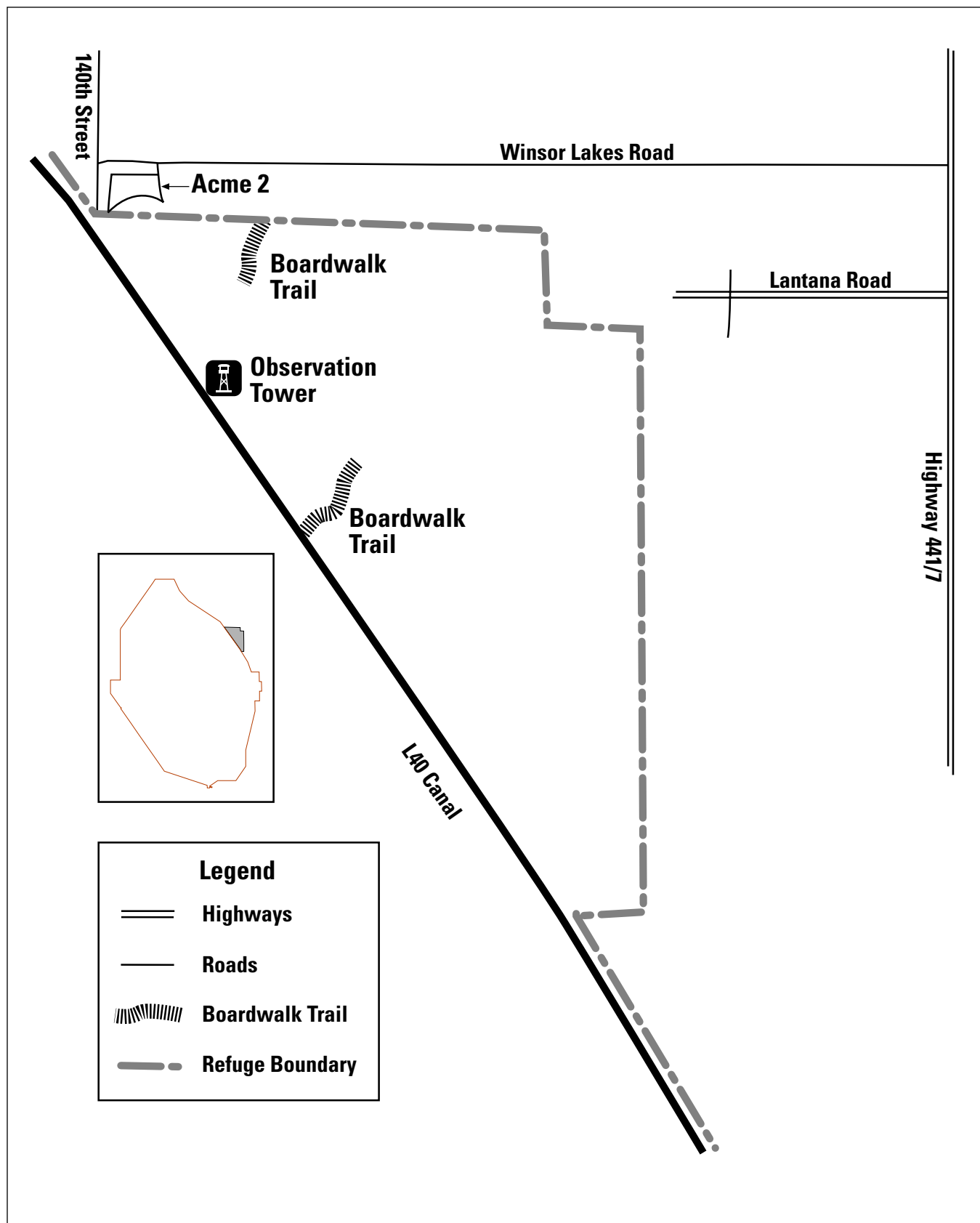


Figure 17. Expanded public use opportunities at Strazzulla Marsh, A.R.M. Loxahatchee National Wildlife Refuge.



3. Develop a hiking and bicycling trail on the existing main levee.
 - Continue the newly opened bicycle use of the perimeter levee from the Headquarters Area to Hillsboro Area (*Figure 18*).
 - Permit hiking use of the main levee from Hillsboro Area northwest to the S-6 Pump. Hiking is also allowed from Hillsboro Area to the ACME 1 Pump Station which is northeast of Strazzulla Marsh (*Figure 18*). Parking access may be developed in partnership with the Village of Wellington and the ACME Drainage District.
4. In cooperation with state and county natural resource agencies, develop a Contact Station and Interpretive Center at the Hillsboro Area. Also, a limited concession contract will be awarded to expand appropriate and compatible wildlife-dependent recreational opportunities at the Hillsboro Area.
 - The Contact Station and Interpretive Center will provide a refuge presence at the Hillsboro Area, and give interpretation to the differences between Water Conservation Areas 1, 2, and 3 and nearby Wildlife Management Areas. The building would provide offices, public telephones, and restroom facilities.
 - The concession contract may include a limited number of motorboat, canoe, kayak and bicycle rentals, fishing gear, and a seasonal pontoon boat shuttle service with interpretive guides between Hillsboro, Headquarters and the Strazzulla Marsh Areas.
5. The refuge will provide appropriate, compatible, wildlife-dependent fishing and hunting opportunities (*Figure 19*).
 - Develop a Hunt Plan for Alligators and Feral Hogs and update the Waterfowl and Fishing Plans by 2002.
 - Permit up to four small fishing tournaments per year.
 - Redefine the boundaries of the waterfowl hunt area to make it more accessible.
 - Eventually increase waterfowl hunt area accessibility by developing paths through the invasive cattail area on the east side of the refuge interior (depending on water quality improvement in the perimeter canal).
6. Develop an environmental education curriculum by 2002, for use on and off the refuge that centers on providing an understanding and appreciation of the Everglades, the refuge's ecology, and the human influence on ecosystems of southeast Florida. This plan will follow guidelines from the National Outreach Strategy and be part of a strategy to reach key community leaders such as teachers, school board members, elected officials, and the news media.
 - Update Environmental Education and Interpretation Plan by 2002.
 - Increase educational opportunities with an enhanced and expanded environmental education/visitor center and a teaching pavilion near the Marsh Trail in the Headquarters Area.
 - Expand educational topics to include water quality and exotic and invasive plant impacts on the natural environment.
 - Update the environmental education manual to include the Strazzulla Marsh and Hillsboro Area.
 - Initiate teacher in-service training using the refuge as an outdoor classroom.
 - Make the most effective use of Service resources (for example, teaching teachers). Support specific Service resource priorities as outlined in the Outreach Strategy.
 - To assist visiting teachers and promote a 'leave no trace' ethic, increase liaisons with county and private school boards to implement a volunteer education and guide program.

- Coordinate satellite downlinks with the Service and area schools, and create a downlink site when a refuge classroom is available.
 - Create and maintain an interactive web site.
 - With the assistance of the regional archaeologist and local Native American communities, develop an education program highlighting Native American cultural heritage as it pertains to the refuge.
7. Upgrade and expand the interpretive program, portraying the significance of the refuge and threats affecting the refuge and the south Florida ecosystem. The interpretive program will be updated using the guidelines from the Fish and Wildlife Service National Outreach Strategy.
- Enhance refuge literature, ensuring updated information about the Service and National Wildlife Refuge System missions.
 - Provide multi-lingual brochures and other handouts.
 - Promote and expand interpreted tours.
 - Enhance and enlarge the Volunteer Speakers Bureau.
 - Explore opportunities of greater public investment in the refuge such as a lifetime pass and an “Adopt-a-Refuge” program.
 - Repair, replace, and improve interpretive signs.
 - Create interpretive signs or kiosks to explain the impoundment management regime at the Headquarters Area and to explain the natural areas of Hillsboro and Strazzulla Marsh.
 - Enhance the current media and elected officials outreach program.

Goal 4. Administration

Continue a partnership with the South Florida Water Management District, including renewal of the license agreement for Water Conservation Area 1. Continue the development of an effective and productive staff to achieve the vision, goals, and objectives of this plan.

Discussion:

Successful negotiations with the South Florida Water Management District that lead to signing a new license agreement are fundamental to the implementation of this plan. The license agreement will allow the Service to continue managing the wildlife and associated habitats in Water Conservation Area 1 as the A.R.M. Loxahatchee National Wildlife Refuge for years to come. Also important to the successful management of the refuge is the continued development of an effective staff.

Objectives:

1. Work with the South Florida Water Management District to sign a new license agreement.
2. Expand current staff to accomplish additional priority refuge operations and maintenance.
3. Continue developing internal Service and external partnerships to share equipment and manpower.

Figure 18. Public use opportunities and land use zones on the L-40 and L-39 Levees, A.R.M. Loxahatchee National Wildlife Refuge.

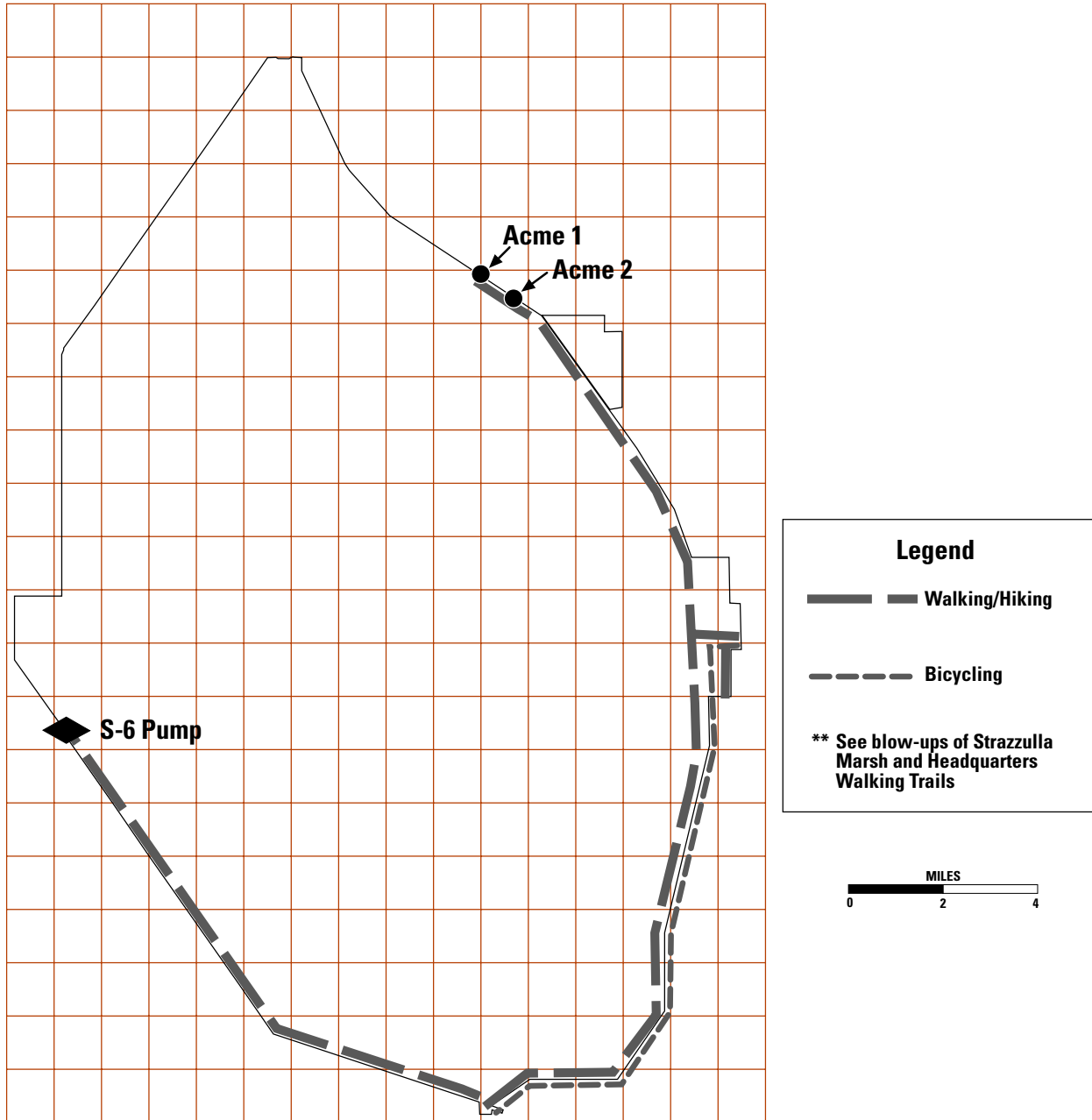
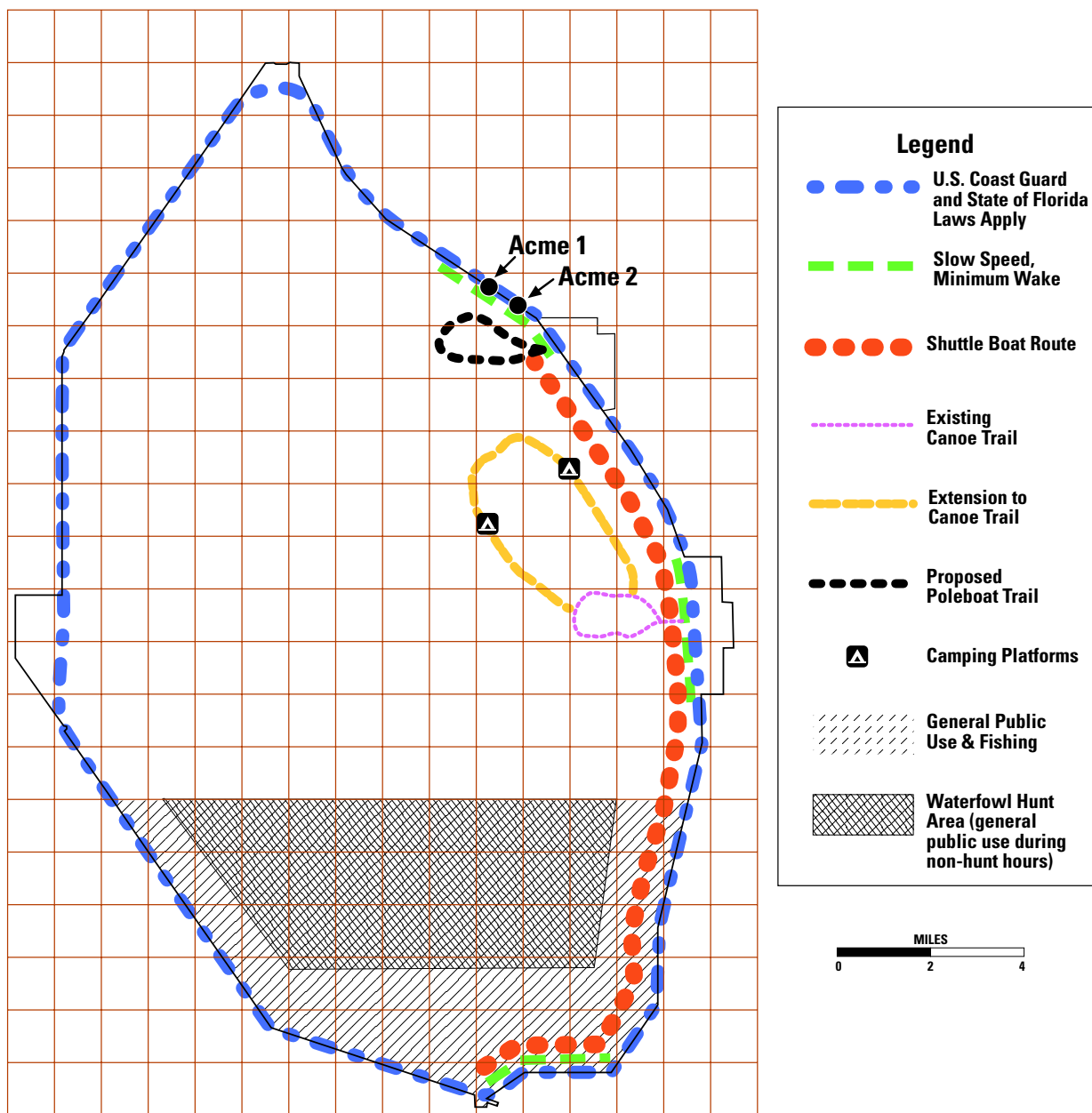


Figure 19. Expanded public use opportunities and waterway zones, A.R.M. Loxahatchee National Wildlife Refuge.



V. Plan Implementation

The future of this and most national wildlife refuges is dependent upon a public constituency that is knowledgeable of refuge resources and mandates, as well as environmental issues, and is willing to work toward resolving them. To build and maintain this needed constituency, this plan not only provides actions to protect, restore, and conserve wildlife habitat, but also to expanded educational and appropriate, compatible, wildlife-dependent recreational opportunities. Developing partnerships among our



Nesting Great blue herons
USFWS Photo

constituencies is the common thread to implementing these actions and opportunities. Promoting the refuge as an asset of Palm Beach County will enhance the refuge's image and help expand local support. To achieve the management plan for the refuge, this section identifies projects, staff development and equipment needs, staffing and funding needs, partnership opportunities, step-down management plans, and a biological monitoring and evaluation plan.

Project Summaries

Listed below is a prioritized list of project summaries and their associated costs for biological baseline data collection, habitat restoration and management, environmental education and interpretation, invasive exotic plant

and animal control, expanded wildlife-compatible recreational opportunities, land acquisition, and facility development and maintenance over the next 15 years. While this project list is not intended to be all inclusive, it does reflect the basic needs identified by the public (two comment periods), planning team members, and refuge staff based upon available information. These projects were generated for the purpose of achieving refuge objectives and strategies, and the primary linkages of these projects to those planning elements are identified in each summary. Additionally, these projects are the basis for funding requests from the U.S. Congress, which must be approved by the Fish and Wildlife Service, the Department of the Interior and the President's Office of Management and Budget, before being forwarded to Congress. The following project descriptions are listed in order of priority, and derived mostly from public comments and comments from government and non-government agencies in response to the Draft Comprehensive Conservation Plan for A.R.M. Loxahatchee National Wildlife Refuge.

Wildlife Habitat and Population Management

Project 1. Invasive Exotic Species Control

1a. Invasive Exotic Plant Species Control (melaleuca and Old World climbing fern only)

The invasive exotic plant species of melaleuca and Old World climbing fern presently infest nearly 100,000 acres of the refuge and are expanding at a rate of more than 4,000 acres per year. These plants are out-competing native vegetation and are altering the Everglades ecosystem. Since past research and control efforts have not kept up with the rate of spread of these species, a significant increase in funding for aerial and ground controls is needed. Most recent contracts for ground control cost in excess of \$200 per acre for melaleuca; aerial application \$300-\$400 per acre. In

addition to control efforts, funding is also needed for research related to biological controls in partnership with U.S. Department of Agriculture's research and quarantine facilities. The encouraging news, as least as it relates to melaleuca, is that there are several promising insects that feed specifically on this species that may be used as bio-controls. Unfortunately, there are no known bio-controls for Old World climbing fern, and labor intensive control is approximately \$500 per acre. To effectively tackle this significant threat to refuge habitats, \$3,000,000 will be needed for at least 5 years to tackle the bulk of the infestation while bio-controls are tested on melaleuca and discovered for Old World climbing fern. Lesser amounts of funding will be needed for maintenance control of the new growth. An ecologist, knowledgeable in exotic plants and animals, will be needed (\$61,300). In addition, mapping is needed to understand existing conditions, to plan control strategies, to evaluate habitat conditions; and to provide long-term monitoring. A one-time mapping contract would cost \$280,000 and would need to be updated every 5 years. The hope is that 5 years of significant funding towards mechanical and herbicidal control will allow enough time for research efforts to produce bio-controls that will work effectively. Obviously, if bio-controls can be introduced earlier, funding could be reduced. After 5 years, funding would still be needed to enable maintenance control of existing invasive exotics and to be pro-active in response to new threats. The subtropical environment of south Florida is conducive to the growth and establishment of exotic plant species. Close monitoring and action is needed to prevent future exotic threats from reaching epidemic proportions. The estimated cost of this project is \$3,340,000 for the first year and \$3,000,000 for the next 5 years until the bulk of the infestation can be reduced to maintenance control levels. The recurring base or annual funding for maintenance control should be around \$500,000 per year by current estimates (Linkage: Goal 1, Objectives 1, 3,5,8).

1b. Other Invasive Exotic Plant Species Control

Beyond the daunting melaleuca and Old World climbing fern problems, there are other invasive exotic plant infestations that negatively impact natural refuge habitats. Water lettuce and water hyacinth clog waterways on the refuge, and hydrilla and other invasive exotic plants impact management in other areas. Brazilian pepper, wild guava, bishopwood, earleaf acacia and other species infest wetlands and dike areas. The extent of these impacts is not well known. This project would survey these invasive exotic plants at a cost \$10,000, with updates needed every 5 years. The survey would assist the refuge in focusing treatment and controlling these other exotic plants. The estimated cost for this project is \$10,000 with recurring costs of \$1,500 per year (Linkage: Goal 1, Objective 8).

1c. Invasive Exotic Animal Species Control

Very little is known about the ecology, range, or abundance of most of the 89 species of Florida's non-indigenous aquatic animals, including those that inhabit the refuge. Walking catfish, oscar, tilapia, black acara, and others have infested the refuge waters for years (*Table 23*). Exotic fish species are discovered each year and it is thought that these species pose a threat to biodiversity on par with habitat loss and degradation. Serious new threats include the Asian swamp eel, a South American armored catfish, and a bromeliad weevil which are poised to infiltrate the refuge waters and vegetation. This survey would need to be updated every 5 years. In addition, mapping is needed to understand existing conditions, plan control strategies, evaluate habitat conditions, and provide long-term monitoring for these exotic animals. The estimated cost for this project is \$10,000 with recurring costs of \$1,500 a year (Linkage: Goal 1, Objectives 4, 8).

Project 2. Water Quantity, Timing, Delivery, and Quality Monitoring

A hydrological computer model is needed to predict the potential impacts to wildlife and habitats under the new Everglades hydrologic regime. This model would enable managers to recommend changes in the regime that would minimize impacts and provide critical data to evaluate long term impacts to the refuge under different restoration alternatives (\$200,000 per year for five years). Increased water quality monitoring is needed for pesticides, herbicides, fertilizers, heavy metals in canal inflows, exotic plant treatment areas, cypress swamp inflows, and in the compartments. This will include analyzing water and soils as well as body burdens in fish, amphibians, and waterfowl (\$75,000). The total estimated cost for this project is \$275,000, with recurring costs of \$200,000 per year (Linkage: Goal 1, Objectives 2,6; Goal 2, Objective 1; Goal 3, Objective 6).

Project 3. Base Maintenance

With the expanded operations and facilities benefitting resource and public use programs via this Comprehensive Conservation Plan, there is a need to develop an effective, pro-active maintenance program. Additional funding is needed to maintain existing refuge facilities, infrastructure, equipment and vehicles as well as expand and maintain the refuge's water and sewage treatment plants. A minimum level of parts and supplies needs to be available for immediate use. Comprehensive inspections of all buildings, vehicles, and equipment need to be implemented to enable long-term use. Costs for this additional support will be \$100,000 per year (Linkage: Goal 4, Objectives 2,3).

4. Expand Environmental Education and Outreach

To accommodate the increasing interest in environmental education by the expanding school systems in south Florida, a new curriculum, developed for use by educators on and off the refuge, will center on conveying the importance of the Everglades and refuge habitats as well as the impacts of human development. An open air pavilion will be constructed near the marsh trail for teaching visiting school classes. Outreach opportunities will be expanded and enhanced through public service materials, brochures, and a web site to reach 6 million (and growing) south Florida residents, as well as the million more tourists who visit annually. Costs for construction and start-up will be \$150,000, with recurring costs of \$10,000 per year (Linkage: Goal 3, Objectives 6, 7).

5. Fire Management Program

Fire has historically been a natural part of the Everglades ecosystem. Due to the burgeoning population on the southeast Florida coast and air quality standards, it is difficult to use prescribed fire. However, it is a preferred management tool. Research is needed to better understand different aspects of the natural role of fire in the unique northern Everglades system, the effect of fire on tree islands, and the potential effects of increased loads of phosphorous to topsoil released by fire. Another unique research need is to understand the effect of fire in spreading exotic plants such as Old World Climbing fern and melaleuca and conversely how fire can be used to retard the spread of these exotics. In addition, studies are needed to implement safe and effective prescribed fires, and to design burn units (areas to be burned) and frequency models (determine how often to burn, what the plant communities and wildlife responses would be to fire at different times of the year and under various water depths). The studies would be contracted to a university, the U.S. Geological Survey's Biological Resources Division, or another research partner at \$100,000 per year.

To implement an effective fire management program, a fire management officer (or a prescribed fire specialist) (\$61,300 per year for salary/benefits) is needed with an understanding of the role of fire in the Everglades ecosystem, the constraints exotics place on the system, and the benefits of prescribed burning in restoration of wildlife habitat. A fire technician to assist in this complex program would also be needed (\$33,500 per year

for salary/benefits). Refuge impoundments within Compartments B and C would be burned on a rotational basis to reduce undesirable vegetation and provide quality wildlife habitat. Specific areas of the refuge interior would be burned to reduce the biomass of treated melaleuca and rank cattail vegetation. The initial cost for this project is \$200,000 with recurring costs of \$200,000 per year (Linkage: Goal 1, Objectives 3,5,8; Goal 3, Objective 1).

6. Everglades Restoration Monitoring

The recovery and maintenance of healthy populations of threatened, endangered, keystone/indicator species, and habitats are important goals of the National Wildlife Refuge System and Everglades restoration. All biological data collected on the refuge from its inception would be compiled and entered into a computerized database. Studies would be initiated to gather data on the life histories and habitat uses of key species such as snail kite, alligator, migratory birds, resident wading birds, and fish. Collection of these data will permit the refuge to evaluate the overall success of restoration efforts and guide future management decisions. A biologist would be hired to assist with surveys, data collection and entry, and analysis. Estimated costs include \$120,000 for start-up costs for a biologist and equipment, with recurring costs of \$50,000 per year (Linkage: Goal 1, Objectives 1,2,6,8; Goal 2, Objective 2).

7. Monitor Vegetation Patterns and GIS Database Development

7a. Geographic Information System Database

Geographic Information System technology enables better mapping, evaluation, and presentation of the diverse and dynamic northern Everglades habitats of which the refuge is a part. A Geographic Information System workstation would be acquired to enable staff, researchers, and partners to evaluate multi-layered spatial data including habitat, wildlife, exotic species, and results of management decisions. A Geographic Information System staff position is needed to manage the system and data (\$50,800). Estimated costs are \$90,000 for the first year, with recurring costs of \$60,000 per year (Linkage: Goal 1, Objectives 2,3,4,5,6,7,8; Goal 2, Objective 3).

7b. Monitor Dynamic Northern Everglades Vegetation Patterns

The imperiled northern Everglades is a dynamic system resulting in continuous changes in vegetation patterns in response to hydrology, fire, elevation, and soils. This project will compile data from all past studies on vegetation change in the refuge and re-sample 1-square-mile photo plots. Several studies, conducted on the refuge since the 1940s, can serve as the foundation for future studies. This project, estimated to cost \$60,000 would enable the refuge to gain a greater understanding of ecosystem processes and would assist in making future management decisions. This project would be re-done every 5 years at an estimated cost of \$25,000 to evaluate refuge management as outlined in the Comprehensive Conservation Plan and the Comprehensive Everglades Restoration Plan (Linkage: Goal 1, Objectives 2,3,4,5,6,7,8; Goal 2, Objective 2).

8. Actively Manage Compartments and Impoundments

Management Compartments A, B, C, and D comprise 2,550 acres of habitat available for more intensive management. One of the least represented components of the historic system is forested wetlands. Compartments A and possibly B could be replanted in cypress, pond apple, red maple, and other trees native to the appropriate plant community (\$70,000). A mosaic of habitats will be created in other areas through active water manipulation and prescribed burning to provide foraging needs of migrating shorebirds, nesting wading birds, waterfowl, and raptors. Thirteen impoundments totaling 725 acres need to have several water control structures replaced or repaired (\$70,000). New pumps are needed at both the north and south ends (\$325,000) and all perimeter canals need to be rehabilitated (\$170,000) to improve water delivery. A seepage pump with automatic settings is needed at Compartment D to facilitate

water management and minimize seepage/flooding impacts to neighboring landowners. In order to effectively manage water and maintain water facilities, a maintenance position would be needed (\$43,300). Heavy equipment such as an excavator, bulldozer, and tractor need to be acquired (\$410,000). The estimated cost for this project is \$1,088,300 with recurring costs of \$110,000 per year. In addition, staff would provide technical assistance and help develop grants and partnerships with state, regional, county, and private landowners to enhance habitat management for trust species throughout Palm Beach County and the surrounding area (Linkage: Goal 1, Objectives 3,4,5,7,8; Goal 3, Objective 1).

9. Expand Hunting Opportunities

Developing additional public hunting opportunities for alligator and feral hog will require additional administrative, biological, and law enforcement effort and overtime costs. Increasing accessibility at the south end of the refuge for waterfowl hunting will require establishing contracts for trail maintenance, but will not be done until water quality reaches acceptable levels on a consistent basis. The estimated cost of this project is \$50,000 with recurring costs of \$15,000 per year (Linkage: Goal 3, Objectives 4,5).

10. Boundary Line Survey

Several portions of the refuge boundary have become overgrown with vegetation or impacted by adjoining developments. At least 20 miles of boundary would be marked and posted to clearly identify the refuge boundary. Estimated cost is \$75,000 (Linkage: Goal 2, Objectives 3,5,6,7).

11. Hillsboro; Develop a Contact Station and Interpretive Center

This southernmost access point to the refuge is heavily used by residents from Palm Beach and Broward counties. While the parking lot has been graveled and existing boat ramps are scheduled for replacement, facilities are still limited. A new information center would be built for refuge staff, volunteers, and refuge support groups. This center would provide information about the refuge and would assist in increasing visitor security, reduce vandalism and decrease other illegal activities. Efforts would be made to partner with the Florida Fish and Wildlife Conservation Commission, South Florida Water Management District, and local agencies to convey the value of the Everglades and major restoration efforts, contrast the unique differences between Water Conservation Areas 1,2, and 3, and adjacent Wildlife Management Areas. A refuge ranger position (\$41,400) would be filled to provide environmental education, interpretation, and coordination. Projected start-up costs will total \$241,400, with recurring costs of \$50,000 per year (Linkage: Goal 3, Objectives 3,6,7).

12. Land Acquisition

To protect the integrity of the refuge, it is necessary to acquire nearby lands from willing sellers or enter into management agreements with other government entities. Staff are particularly concerned about extending the refuge boundary to include a narrow strip of land (about 680 acres), or entering into a partnership to manage the lands just east of the visitor center and refuge impoundments. Such lands would buffer the effects of urban development adjacent to the refuge. While several efforts are underway to acquire lands along the eastern boundary, either as water preserve areas (as part of the Comprehensive Everglades Restoration Plan) or as environmentally sensitive lands (as part of Palm Beach County's Agricultural Reserve Program), there is always the possibility that this land may not be acquired under these programs. If this is the case, leases, easements, or management partnerships are the preferred choices to protect these lands. However, the refuge would still be interested in acquiring these lands from willing sellers. Land purchase estimates could range between \$2 - 6 million. Lands acquired could be managed as natural wetlands or replanted with trees to restore the forested wetland component of the Everglades (Linkage: Goal 2, Objective 3; Goal 1, Objective 8).

13. Develop Strazzulla Marsh Visitor Facilities

Additional access and public use facilities are needed at the north end of the refuge to accommodate people residing to the north and the west of the refuge, particularly in the Village of Wellington and other nearby Palm Beach County communities. Facilities will be developed for compatible, wildlife-dependent recreation, including a disabled-accessible fishing pier, elevated observation tower and boardwalk, possibly a poleboat launch, interpretive panels, information and directional signing, and restrooms. This development will also serve as an access point for hiking use associated with the hiking trail. Public access and a vehicle parking lot may be developed in partnership with the Village of Wellington and the ACME Drainage District. A maintenance person would be hired for the upkeep and repair of this and other refuge facilities. Estimated costs would be \$275,000 for construction and start-up, with salary and maintenance costs running \$40,000 per year (Linkage: Goal 3, Objectives 2,5,7).

14. Expand Hillsboro Recreational Activity Facilities

A contract would be awarded to establish a concession operation. This concession may provide a limited number of the following recreational opportunities: canoe and boat rentals, fishing equipment and guides, bicycle rentals, and interpretive pontoon boat trips up to the Headquarters and Strazzulla Marsh areas. The concessionaire, as the refuge develops the appropriate partnerships, may also supply equipment, rentals, and guides to support recreational opportunities in Water Conservation Area 2 which is adjacent the refuge and extensively accessed within 50 yards of the Hillsboro Area entrance. A law enforcement officer would be stationed at this site to ensure visitor safety and resource protection (\$46,200). Projected start-up costs will run \$108,600, with recurring costs of \$37,600 per year (Linkage: Goal 3, Objectives 3,4,5).

*Data collection
USFWS Photo by M. Bailey*



15. Expand Headquarters Visitor Facilities

While the refuge has the second highest visitation among outdoor attractions in Palm Beach County, its visitor center is limited in its ability to provide interpretive exhibits and programs to a rapidly expanding nearby population of 6 million people. Construction of an additional building, to mirror the existing one, will double the space to 5,000 square feet and provide an expanded display area with interactive exhibits, classrooms, “wet labs,” larger auditorium, expanded cooperating association sales area, and additional office and storage space. The Service will contract for construction of the building (\$650,000) as well as new exhibits (\$400,000). Existing levees will be opened for wildlife observation and hiking in Compartment A and interpretive signs will be installed (\$25,000). A senior public use specialist (\$70,300 per year) is needed to coordinate outreach, planning, and interpretive programs for the refuge (as well as for its “satellite” refuge, Hobe Sound National Wildlife Refuge, which is administered by Loxahatchee refuge). In addition, a park guide (\$39,600) would be hired to assist with the expanded interpretive tours and programs. The existing canoe trail will be extended and two camping platforms (\$16,000 each) and two composting toilets (\$3,000 each) will be added to allow overnight platform camping. The canoe trail will need to be maintained at least three times per year (\$10,000) with a mechanical cutting machine and \$10,000 will cover overall program administrative costs. The cost of the canoe trail extension and camping platforms will be \$58,000. The total cost for this project is \$1,274,000 with recurring costs of \$160,000 per year (Linkage: Goal 3, Objectives 1,3,6,7).

Table 8. Cost summary of the projects for the refuge

The Initial Project Cost is the projected sum for getting the project started the first year. The Recurring Base Cost is the amount that will be incurred each year thereafter to continue the project.

<i>Projects</i>	<i>Initial Project Cost</i>	<i>Recurring Base Cost</i>
1. Invasive Exotic Species Control	\$3,340,000	\$3,000,000 *
2. Water Quantity, Timing, Delivery and Quality Monitoring	275,000	200,000
3. Base Maintenance	-----	100,000
4. Expand Environmental Education and Outreach	150,000	10,000
5. Fire Management Program	200,000	200,000
6. Everglades Restoration Monitoring	120,000	50,000
7. Monitor Vegetation Patterns/GIS Database Development	150,000	60,000
8. Actively Manage Compartments and Impoundments	1,088,300	110,000
9. Expand Hunting Opportunities	50,000	15,000
10. Boundary Line Survey	75,000	-----
11. Hillsboro; Develop a Contact Station and Interp.Center	241,400	50,000
12. Land Acquisition	2 to 6,000,000	-----
13. Develop Strazzulla Marsh Visitor Facilities	275,000	40,000
14. Expand Hillsboro Recreational Activity Facilities	108,600	37,600
15. Expand Headquarters Visitor Facilities	1,274,000	160,000
<i>Grand Total</i>	<i>\$7,347,300</i>	<i>\$4,032,600</i>
<i>without land acquisition</i>		<i>\$9,347,300</i>
<i>with land acquisition</i>		<i>\$13,347,300</i>

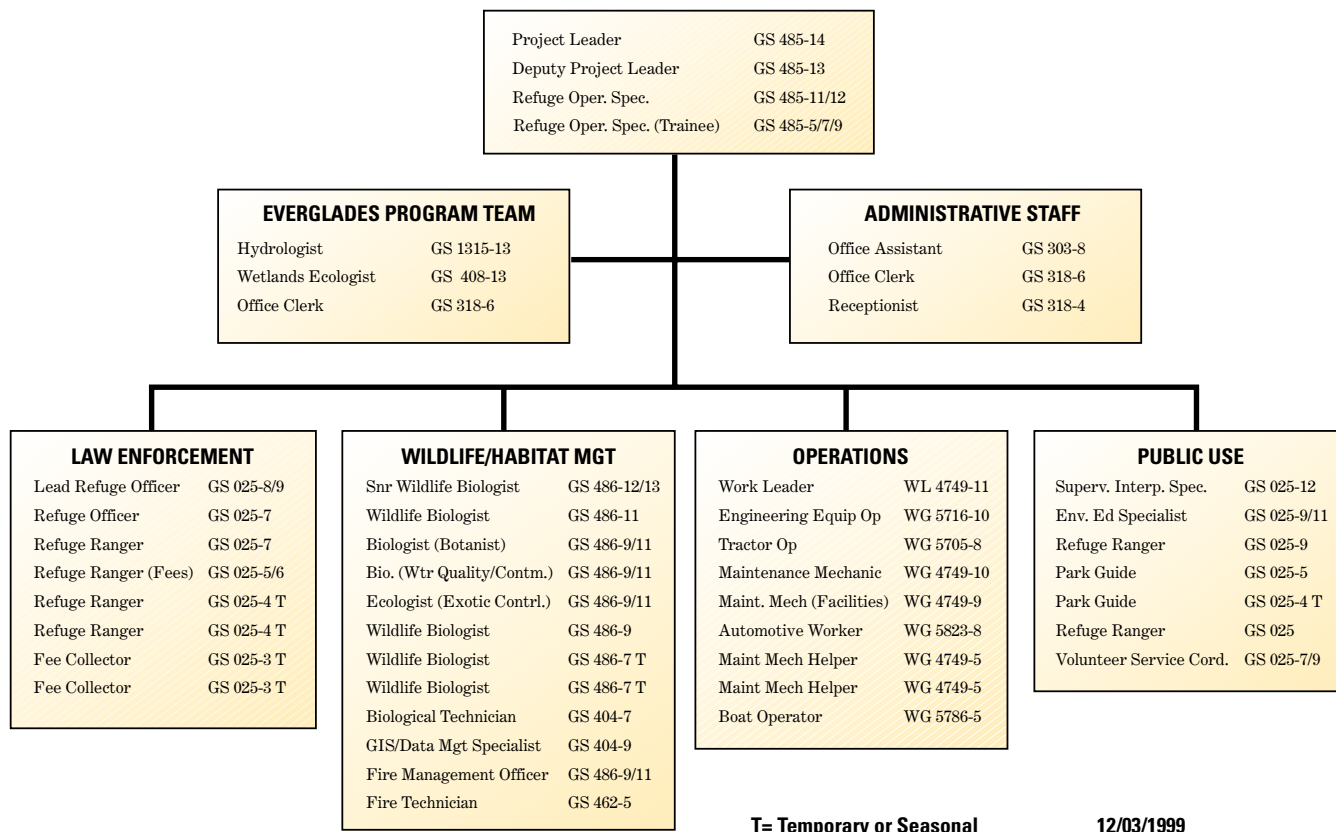
* The Recurring Base Cost for Project 1 will diminish quickly over time as areas are “initially attacked” and as bio-controls are released and become more effective against melaleuca and Lygodium.

* Law enforcement enhanced pay, Salary including benefits (calculated at the highest potential wage possible, using FY-2000 wage scales).

T- temporary or seasonal

Table 9. Annual cost of proposed staff positions for A.R.M. Loxahatchee National Wildlife Refuge

<i>Management</i>	<i>Grade</i>	<i>Annual Cost*</i>
Project Leader	GS-0485-14	\$104,400
Deputy Project Leader	GS-0485-13	\$88,400
Refuge Operations Specialist	GS-0485-11/12	\$74,300
Refuge Operations Specialist (trainee)	GS-0485-5/7/9	\$51,200
<i>Everglades Program Team</i>		
Hydrologist	GS-1315-13	\$88,400
Wetlands Ecologist	GS-0408-13	\$88,400
Office Clerk (EP Team only)	GS-0318-6	\$37,700
<i>Administrative Staff</i>		
Office Assistant	GS-0303-8	\$46,400
Office Clerk	GS-0318-6	\$37,700
Receptionist	GS-0318-4	\$30,200
<i>Law Enforcement</i>		
Lead Refuge Officer	GS-0025-9/11*	\$62,000
Refuge Ranger	GS-0025-7*	\$46,200
Refuge Ranger	GS-0025-7	\$41,900
Refuge Ranger (Fees)	GS-0025-5/6	\$37,700
Refuge Ranger	GS-0025-4 T	\$13,200
Refuge Ranger	GS-0025-4 T	\$13,200
Fee Collector	GS-0025-3 T	\$11,800
Fee Collector	GS-0025-3 T	\$11,800
<i>Wildlife/Habitat Management</i>		
Senior Wildlife Biologist	GS-0486-12/13	\$88,400
Wildlife Biologist	GS-0486-11	\$62,000
Biologist (Botanist)	GS-0486-9/11	\$62,000
Biologist (Water Quality & Contaminants)	GS-0486-9/11	\$62,000
Ecologist (Exotic Control)	GS-0486-9/11	\$62,000
Wildlife Biologist	GS-0486-9	\$51,200
Wildlife Biologist	GS-0486-7 T	\$18,400
Wildlife Biologist	GS-0486-7 T	\$18,400
Biological Technician	GS-0404-7	\$41,900
GIS/Data Management Specialist	GS-0404-9	\$51,200
Fire Management Officer	GS-0486-9/11	\$62,000
Fire Technician	GS-0462-5	\$33,800
<i>Maintenance Operations</i>		
Wage Leader	WL-4749-11	\$52,700
Engineering Equipment Operator	WG-5716-10	\$45,100
Tractor Operator	WG-5716-8	\$39,600
Maintenance Mechanic	WG-4749-10	\$45,100
Maintenance Mechanic (Facilities)	WG-4749-9	\$42,300
Automotive Worker	WG-5823-8	\$39,600
Maintenance Mechanic Helper	WG-4749-5	\$31,200
Maintenance Mechanic Helper	WG-4749-5	\$31,200
Boat Operator	WG-5786-5	\$31,200
<i>Public Use</i>		
Supervisory Interpretive Specialist	GS-0025-12	\$74,300
Environmental Education Specialist	GS-0025-9/11	\$62,000
Refuge Ranger	GS-0025-9	\$51,200
Refuge Ranger	GS-0025-7	\$41,900
Park Guide	GS-0025-5	\$33,800
Park Guide	GS-0025-4 T	\$13,200
Volunteer Services Coordinator	GS-0025-7/9	\$51,200
Subtotal (annual staff costs)		\$2,183,800
Annual fixed costs (phone, gas, diesel, electric, travel, equipment repair, equipment and building maintenance, etc.)		\$185,000
Total Annual Cost		\$2,368,800

Figure 20. Proposed staffing plan for A.R.M. Loxahatchee National Wildlife Refuge**Staffing and Funding**

Currently a staff of 23 permanent and 13 temporary/seasonal positions has been approved by the regional office for the refuge, but current funding covers only 20 permanent and 4 temporary/seasonal positions. In the recent past, most of the temporary/seasonal personnel have been used for melaleuca control or for the entrance fee program. Since the plan calls for contracting out exotic species control, and fee collection procedures and compliance monitoring have been improved, the number of “seasonals” was reduced to four positions.

To complete the extensive wildlife management and restoration projects and increase inventorying, monitoring, and mapping projects more permanent staff will be needed, including a refuge operational specialist, an office clerk, a receptionist, a law enforcement refuge ranger, a botanist, an ecologist, a wildlife biologist, a geographic information system specialist, a fire management officer, a fire technician, a wage leader for the maintenance staff, a tractor operator, a maintenance mechanic, a maintenance mechanic helper, a boat operator, an interpretive refuge ranger, a park guide, and a volunteer services coordinator. Additional seasonal positions are needed to expand the programs identified in the plan including a refuge ranger (law enforcement) and interpretive park guide during our heavy use periods and two wildlife biologists during critical census/inventory time periods. The staffing plan (Figure 20), at full development level, would achieve the plan objectives and strategies within a reasonable time period. The annual costs (salary, including benefits) of the staffing plan is shown in Table 9. The rate at which this refuge achieves its full potential of contributing locally, regionally, and nationally to wildlife conservation; appropriate, compatible wildlife-dependent recreation; and environmental education is totally dependent upon receiving adequate funding and staffing.

Partnership Opportunities

To achieve the goals and objectives of this plan, maintaining existing partnerships and developing new ones with a variety of resource agencies, organizations, and individuals is essential (for a list of existing and potential partners, see Appendix M). Partnerships will not only enable the refuge to fulfill plan objectives, but also minimize costs.

As reflected in the management objectives, Loxahatchee refuge is one of the key players in the restoration of the northern Everglades. Coordination with agencies, organizations, and individuals involved with Everglades restoration will ensure that refuge management remains consistent with ecosystem restoration objectives.

Effective management of water quality, quantity, and timing is critical to achieving wildlife habitat and population objectives in the refuge interior. To these ends, partnerships will be developed with adjacent landowners, South Florida Water Management District, Lake Worth Drainage District, Corps of Engineers, and the Florida Department of Environmental Protection. To maintain and enhance wildlife habitat outside of the refuge, the Service will focus its efforts on developing partnerships with the Village of Wellington and farmers in the Everglades Agricultural Area.

Effective management of exotic plants will depend on developing key partnerships with other local, state, and federal agencies and universities and conservation organizations. These partnerships will provide for an extensive base of knowledge and expertise to assist the refuge in organizing its exotic plant management efforts. The refuge works closely with the South Florida Water Management District, U.S. Department of Agriculture, National Park Service, Department of Environmental Protection, and University of Florida researchers and scientists concerning exotic plant research and monitoring, and exotic plant treatments for melaleuca, Old World climbing fern, and floating exotic plants. Research scientists from the U.S. Department of Agriculture and the University of Florida assist refuge staff to identify exotic plants, recommend herbicides and treatment methods, coordinate biological control releases and monitoring, and assist with research on the effects of exotic plants on native plants and wildlife. The refuge has just begun a partnership with the Lake Worth Drainage District on levee maintenance, native plantings, and chemical treatment of exotic floating plants. They have also assisted with the removal of Brazilian pepper using heavy equipment around refuge impoundments. The refuge hopes to develop partnerships with adjoining landowners and neighbors to establish “exotic free” buffers adjacent to the refuge.

Collaboration with colleges, universities, and conservation organizations will enable the refuge to carry out its extensive plans for research, monitoring, and education. To create awareness and expand environmental education efforts in the community, partnerships will be established with school systems and organizations. The refuge’s existing relationship with its cooperating association, the Loxahatchee Natural History Association, will be enhanced and similar partnerships will be pursued with other support groups to meet other refuge needs.

Table 10. Step-Down Management Plans and completion dates, arranged by issue sequence in the goals and objectives portion of the plan.

<i>Step-Down Plan</i>	<i>Completion Date</i>
Integrated Pest Management Plan	2002
Exotic Plant Control Plan	2002
Exotic Animal Control Plan	2002
Water Quality Monitoring Plan	2002
Biological Inventory/Monitoring Plan	2003
Moist Soil/Water Management Plan	2002
Fire Management Plan (Update)	2002
Law Enforcement Plan	2002
Cultural Resource Protection Plan (Update)	2003
Public Use Management: General Plan (Update)	2005
Public Use Management: Environmental Education Plan (Update)	2002
Public Use Management: Fishing Plan (Update)	2004
Public Use Management: Hunt Plan (Update)	2004
Alligator Hunt Plan	2004
Feral Hog Hunt Plan	2004
Waterfowl Hunt Plan (Update)	2004
Public Use Management: Signs (Update)	2004

Step-Down Management Planning

A comprehensive conservation plan is a strategic plan that guides the future direction of the refuge. Before some of the strategies and projects can be implemented, detailed step-down plans will need to be prepared or updated. To assist in preparing and implementing the step-down plans, refuge staff will develop partnerships with local agencies and organizations. These plans, listed in Table 10 and described below, will be developed in accordance with the National Environmental Policy Act, which requires the identification and evaluation of alternatives and public involvement prior to their implementation.

Integrated Pest Management Plan

Draft Completion 2002

This plan will address the complex issue of bringing exotic plants and animals to a maintenance control level on the refuge. It will cover chemical herbicide use (aerial and ground level), mechanical eradication, and the use of bio-controls. The Exotic Plant and the Exotic Animal Control Plans will be sections within this plan.

Exotic Plant Control Plan (Update)

Completion 2002

This plan (as part of the Integrated Pest Management Plan) will bring exotic and invasive plants to a maintenance control level as soon as possible. It will identify current infestation levels of the major exotic or invasive plants on the refuge and outline methods for controlling and monitoring these plants. Survey and control methods will also be identified for non-major exotic and invasive exotic plants.

Exotic Animal Control Plan

Completion 2002

This plan (as part of the Integrated Pest Management Plan) will describe survey, removal and monitoring techniques for both terrestrial and aquatic invasive and exotic animals (vertebrate and invertebrates).

Water Quality Monitoring Plan

Completion 2002

This plan will address monitoring sites and stations targeted for ongoing research into how the quality of water changes over time. It will state how the various habitat types (cypress swamp, Strazzulla marsh, impoundments and refuge interior) and structures (Stormwater Treatment Area outflows, culverts leading into the cypress swamp, etc.), will be monitored for nutrients, pesticides, and other chemicals which may adversely affect those environments.

It will also include the stipulations set forth in the Consent Decree. This plan will help ensure that all refuge water quality meets the standards of the Department of Environmental Protection and the Environmental Protection Agency for Class III and Outstanding Florida Waters. It will address research and monitoring needs to meet these water quality standards and will more precisely identify the location of monitoring sites, list the frequency of monitoring, and describe the methods of evaluation.

Biological Inventory/Monitoring Plan

Completion 2003

This plan will describe inventory and monitoring techniques and time frames. All plant communities and associations in the refuge as well as all trust species (migratory birds including shorebirds, neotropical passerines, and waterfowl), listed species (federal and state threatened, endangered, and species of concern), and key species shall be inventoried, and population trends will be monitored. These data are essential to guide wildlife habitat management on the refuge.

Moist Soil/Water Management Plan

Completion 2002

This plan will identify the procedures for managing the compartments and the cypress swamp for optimal wildlife benefits, including methods, timing, and implementation.

Fire Management Plan

Completion 2002

Updating and implementing this plan will result in more aggressive wildlife habitat management in the refuge interior. This plan will also include fire management in other areas of the refuge, including all the compartments and Strazzulla Marsh.

Law Enforcement Plan

Completion 2002

Updating this plan will reflect objectives and strategies of the comprehensive conservation plan.

Cultural Resource Protection Plan

Completion 2003

This plan will identify and seek to protect archeological sites. Development of this plan, written by the Service's Regional Archaeologist, will involve consultation with federally recognized Native American Nations, the State Historic Preservation Office, and other professional archaeologists.



*Monitoring vegetation density
USFWS Photo by M. Bailey*

Public Use Management: General (Update)

Completion 2005

This plan will address appropriate, compatible, and wildlife-dependent recreation issues including facility upgrades, handicapped accessibility, types of recreation, accessibility, and concession usage.

Environmental Education Plan

Completion 2002

This update will reflect the objectives and strategies of the comprehensive conservation plan and address environmental education guidelines following Sunshine State standards. As a part of this plan, an education manual will be created that follows the plan and Fish and Wildlife Service guidelines for environmental education.

Hunt Plan and Fishing Plan

Completion 2004

This updated plan will reflect the Comprehensive Conservation Plan's objectives and strategies regarding select species including alligators, feral hogs, and waterfowl. It will identify species to be hunted, seasons, limits (dependent upon biological survey findings), hunt areas, accessibility, hunt methods, and other regulations applicable to species hunting regulations. This update will address specific aspects of the refuge fishing program including boat speeds, fishing boundaries, needed facilities, and applicable fishing regulations.

Sign Plan (Update)

Completion 2004

In this plan, signs will be redesigned, incorporating Fish and Wildlife Service guidelines.

Monitoring and Evaluation

Effective long-term management of the refuge will depend on baseline inventories and periodic monitoring and evaluation of refuge resources.

Data generated from inventory and monitoring efforts will enable refuge staff to determine the status and trends of key species and habitats. These data will be incorporated into a geographic information system, which will enable refuge staff to evaluate the effects of alternative habitat management techniques, exotic plant control methods, and changes in water quality on these species and habitats.

These efforts will enable the refuge to evaluate the achievement of the proposed objectives and strategies identified in the Comprehensive Conservation Plan, if necessary make adjustments in the plan, and test new management techniques. Thus, adaptive management, as it is called, is a flexible approach to the long-term management of resources that is guided by the results of ongoing inventory and monitoring activities.

The primary direction the biological inventorying and monitoring plan will follow is governed by the Service Refuge Manual and the “Fulfilling the Promises” and “Biological Needs Assessment” (internal management) documents. Issues such as the Everglades restoration and regional protection of listed, trust, and focal species are referenced in the South Florida Ecosystem Team’s Ecosystem Plan, South Florida Multi-Species Recovery Plan, and the Comprehensive Ecosystem Restoration Monitoring Plan. All these documents assist refuge management and the refuge biological program to focus inventory and monitoring plans with limited resources.

The following is a list of guidelines and steps refuges use to determine which habitats and species are inventoried and monitored. (Note: Inventory and monitoring projects are sometimes specific to the refuge, while others support regional, national, and international emphasis.)

- Those habitats or species listed in the Refuge Purpose (wildlife habitat and migratory birds)
- The habitats and species of critical management importance. Usually this means the primary trust species (federally listed threatened and endangered species, migratory birds, anadromous fish, and certain marine mammals) which reside on or are dependent upon the habitats found on the refuge (e.g., snail kite, wood stork)
- Secondary trust species (federally listed threatened and endangered species, migratory birds, anadromous fish, and certain marine mammals) which occasionally may use the refuge (e.g., bald eagle, crested caracara)
- State listed species (e.g., Florida sandhill crane, strap fern), Species of Management Concern (e.g., yellow rail, American bittern) and species listed under CITES (e.g., river otter, delicate ionopsis)
- Those habitats or species of concern in the South Florida Ecosystem Team’s Ecosystem Plan, South Florida Multi-Species Recovery Plan and the Comprehensive Ecosystem Restoration Monitoring Plan (e.g., tree islands, wading birds, alligators). These focal habitats and focal species were selected because they can provide information and indicate changes on larger communities and ecological processes.

Adjustments will be made to phase out less productive efforts and include methods providing sensitive indications of population dynamics. Although the refuge is quite large, it is not isolated. Rather, it is an important portion of the greater Everglades ecosystem and surveys will be closely tied to monitoring the restoration efforts.

A limited list of current inventory and monitoring surveys the refuge staff and researchers conduct may be found in Appendix O. The Comprehensive Inventorying and Monitoring Plan will show greater detail in deciding what and how sites or species are selected and how the monitoring will take place.

The Exotic Plant Control Plan includes monitoring and evaluations as well. An exotic plant monitoring program will be key to successful exotic plant management on the refuge. Several projects are currently in the development stage and hopefully will be implemented in 2001. Ten and twelve treated tree islands will be selected for long-term monitoring of Old World climbing fern and melaleuca respectively. Percent coverage of melaleuca, Old World climbing fern, and native plant species will be documented over time in 4 X 5 meter plots in the ground (0-1 meter), shrub (1-2 meters), and over story (>2 meters) vegetation layers. The study will help determine the effectiveness of herbicide treatments and help predict the optimal time for re-treatments. Regeneration of melaleuca, Old World climbing fern, and native vegetation in the various layers will also be documented. In addition, photo points will be established on the interior and exterior of the tree islands to document re-growth. Sites will be monitored quarterly.

Another study to monitor impacts of Old World climbing fern on the native vegetation of tree islands in the refuge was completed during 2000 (Brandt, L. and D. Black, South Florida Water Management District). This study examined species richness and percent cover in ground, shrub, and overstory vegetation layers in one 4 X 5 m plot on ten tree islands in refuge. Five tree islands were heavily infested and five islands had very low or no infestation. Species richness was similar between infested and non-infested islands; however, percent cover of native species was significantly reduced on heavily infested plots.

A herbicide efficacy monitoring program will be developed in the near future to document effectiveness of selected herbicides on Old World climbing fern and non-target damage to native vegetation. Similar studies have been conducted in the past by the Florida Park Service at J.D. State Park, by the South Florida Water Management District at Dupuis State Reserve, and by herbicide manufacturers at the Florida Power and Light Company-owned Baley Barber Swamp in Indiantown. Additional experiments of testing and comparing aerial versus ground application techniques for herbicides on melaleuca and Old World climbing fern may also be implemented but this is strictly dependent upon funding availability and increases.

I. Purpose of and Need for Action

As directed by the National Wildlife Refuge System Improvement Act of 1997, Comprehensive Conservation Plans are to be developed for all National Wildlife Refuges by 2012. These plans will identify the role a refuge will play in support of the mission of the National Wildlife Refuge System, and provide guidance regarding its management direction and operations for the next fifteen years.

A Draft Comprehensive Conservation Plan has been developed for A.R.M. Loxahatchee National Wildlife Refuge to address important natural resource, compatible wildlife-dependent recreation, and administrative needs. To be specific, there is a need to restore and conserve the natural diversity, abundance, and function of flora and fauna; conserve natural and cultural resources through protection, partnerships, and acquisition of land from willing sellers; provide opportunities for appropriate, compatible, wildlife-dependent recreation and environmental education programs; and provide effective and efficient administration of the refuge. For background information relating to natural resource needs, refer to Section II of the Draft Comprehensive Conservation Plan.

Critical to meeting the above needs is the renewal of the U.S. Fish and Wildlife Service's license agreement with the South Florida Water Management District, which controls water flow into and out of Water Conservation Area 1, (also known as the refuge) and to the adjacent Strazzulla Marsh. These lands, while not owned by the Fish and Wildlife Service, are managed under the license agreement, the refuge's authorizing legislation and other federal laws.

Purple gallinule
USFWS Photo by Bruce Flaig



II. Proposed Action

Based on the environmental effects analysis of the proposed action (known as the 'preferred alternative' or the Ecosystem Emphasis Alternative 2) along with public comments concerning the significance of these effects, the Regional Director of the Fish and Wildlife Service must decide whether or not the proposed action would have a significant impact on the environment. If the proposed action is not significant, then a Finding of No Significant Impact will be issued, followed by the preparation of a Final Comprehensive Conservation Plan. If the proposed action is significant, then an Environmental Impact Statement will be prepared.

III. Issues and Concerns

For a description of the issues and concerns, refer to Section II, Planning Issues and Opportunities, in the Draft Comprehensive Conservation Plan.

Following the guidelines of the National Environmental Policy Act, issues and concerns were identified by holding a public scoping meeting and by obtaining written comments from the public. The planning team identified a range of reasonable alternatives, evaluated the consequences of each alternative, and chose the alternative which, in the opinion of the Service and the team, is the best approach to guide the refuge's future direction. This planning effort and the refuge team's ongoing dialogue with various federal, state and county agencies, interest groups and individuals provided important elements in the synthesis of the proposed goals, objectives, and strategies found in the Draft Comprehensive Conservation Plan. Implementation of the plan will necessitate further coordination and cooperation with these entities.

IV. Alternatives

Description, Staffing Needs, and Costs

The planning team evaluated four alternatives for achieving the vision. These alternatives, consisting of goals and objectives, are: Alternative 1, Maintain Current Management; Alternative 2, Ecosystem Emphasis; Alternative 3, Biological Emphasis; and Alternative 4, Public Use Emphasis. The alternatives reflect the issues and concerns identified by the planning team, public scoping meeting comments (August 17, 1998, Boynton Beach, Florida), and written comments.

Alternative 2, Ecosystem Emphasis, is the Service's preferred alternative for managing the refuge. Regardless of which alternative is ultimately implemented, the Service will strive to accomplish the objectives set for the 15-year period, assuming that the necessary funding and staffing are obtained.

Described below is a summary of the alternatives and the goals and objectives for each alternative. A comparison of the alternatives by management objectives can be found in Table 15. The staffing, operational, and project costs for the alternatives are found in Table 16.

Alternative 1. Maintain Current Management (No Action Alternative)

Under this plan, hydrologic conditions (water quality, quantity, delivery, and timing) would continue to be monitored with existing programs. Water quality testing will continue in 4 Atmospheric Deposition stations and 16 helicopter stations in the refuge interior, and at the S5-A and Everglades Nutrient Removal Project outflow stations.

Water management will rely upon developing progressive partnerships with the South Florida Water Management District and the U.S. Army Corps of Engineers. A few of the refuge staff would continue to attend meetings and give necessary input on topics that may affect the refuge and other Everglades issues. Due to inadequate funding, the exotic plant control program would continue on a very limited basis through the use of refuge staff or by contract. Refuge personnel would continue to monitor a limited number of high profile wildlife species such as nesting wading birds, alligator nests, and neotropical migratory birds. Limited management around the Marsh Trail would continue resulting in one impoundment managed every other year. Law enforcement personnel and activity would continue to be a priority along with other programs such as exotic plant control and biological programs. Recreation and environmental education activities would continue but function at low levels. Public use programs would continue using inadequate existing facilities, and outdated brochures, educational information, and exhibits.

Goal 1. Wildlife Habitat and Population Management

Objectives:

1. Protect 143,238 acres of refuge habitat (the interior) with the current water regulation schedule.
2. Continue to monitor refuge water quality through the 16 interior helicopter stations, the 4 atmospheric deposition stations, and the Everglades Nutrient Removal Project.
3. Control invasive and exotic plants by staff or by contractors on a limited basis as minimal funding allows.
4. Monitor a limited number of high profile wildlife species such as wading birds, waterfowl, and snail kites.
5. Conduct limited management in Compartment C, Impoundment C-7 (33 acres), and monitor other impoundments for wildlife use.

Goal 2. Resource Protection

Objectives:

1. Protect water resources on the refuge by participating on committees associated with Everglades restoration and by providing input on water quality issues.
2. Protect wildlife and plant communities and minimize species exposure to contaminants by following applicable regulations. Follow current contaminant response plans.
3. Enforce refuge laws and regulations and protect resources, facilities, and the visiting public. Continue limited partnerships with other law enforcement agencies.
4. Develop and implement a cultural resource protection plan congruent with federal and state historic preservation mandates.

Goal 3. Public Use

Objectives:

1. Provide an appropriate compatible, wildlife-dependent recreational experience by maintaining existing facilities. Continue to allow hunting, fishing, wildlife observation, canoeing opportunities, bicycling, and hiking on portions of the perimeter levee (*Figures 21 and 22*).
2. Continue limited environmental education and seasonal programs. Maintain existing interpretive trails and boardwalk.

Goal 4. Administration

Objectives:

1. By October 1, 2000, work with South Florida Water Management District to sign a new license agreement.
2. Maintain current staffing levels to accomplish refuge operations and maintenance.

Figure 21. Alternative 1: Current public use accessibility, A.R.M. Loxahatchee National Wildlife Refuge.

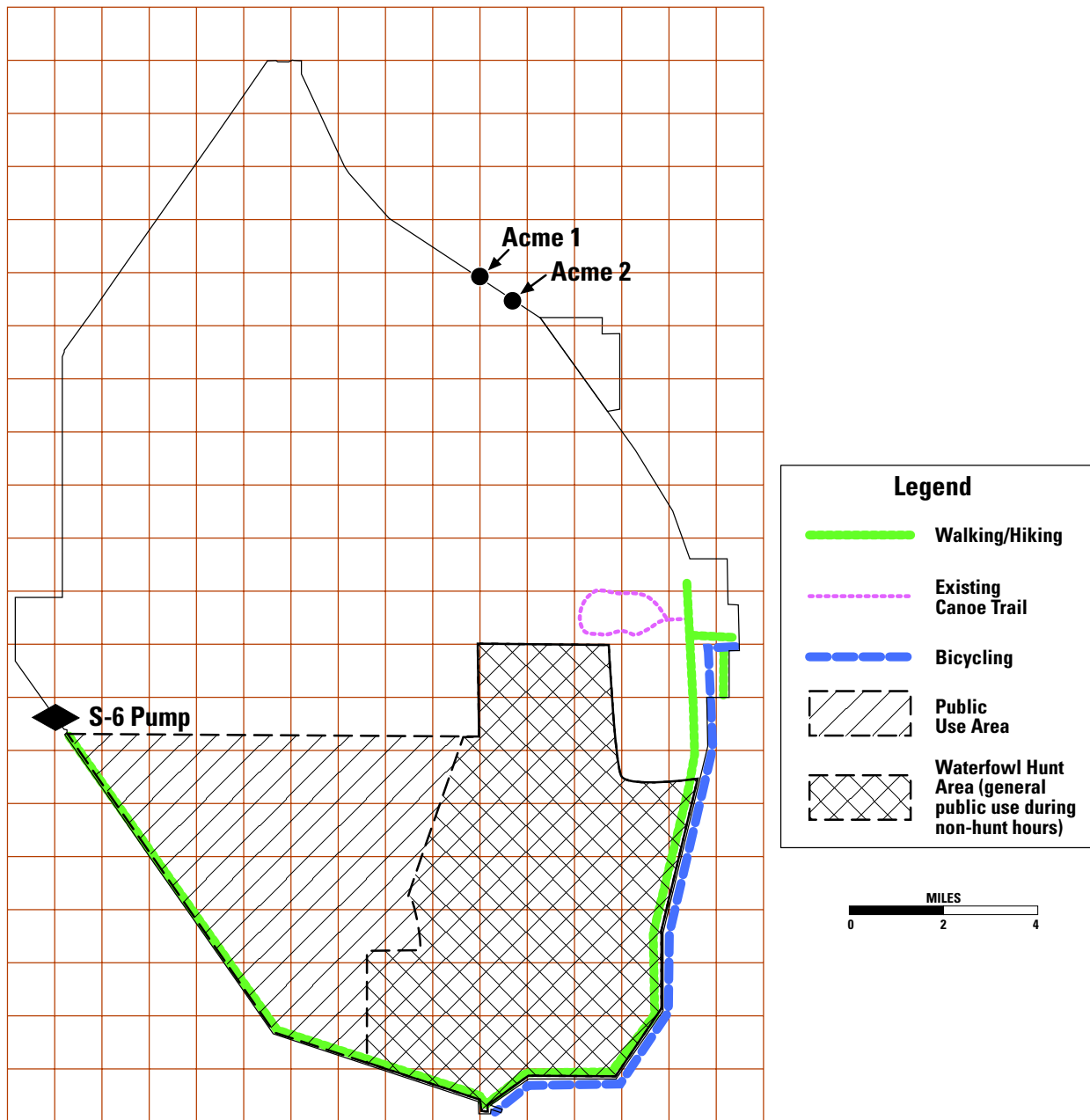


Figure 22. Alternative 1: Public use areas at Headquarters area, A.R.M. Loxahatchee National Wildlife Refuge.

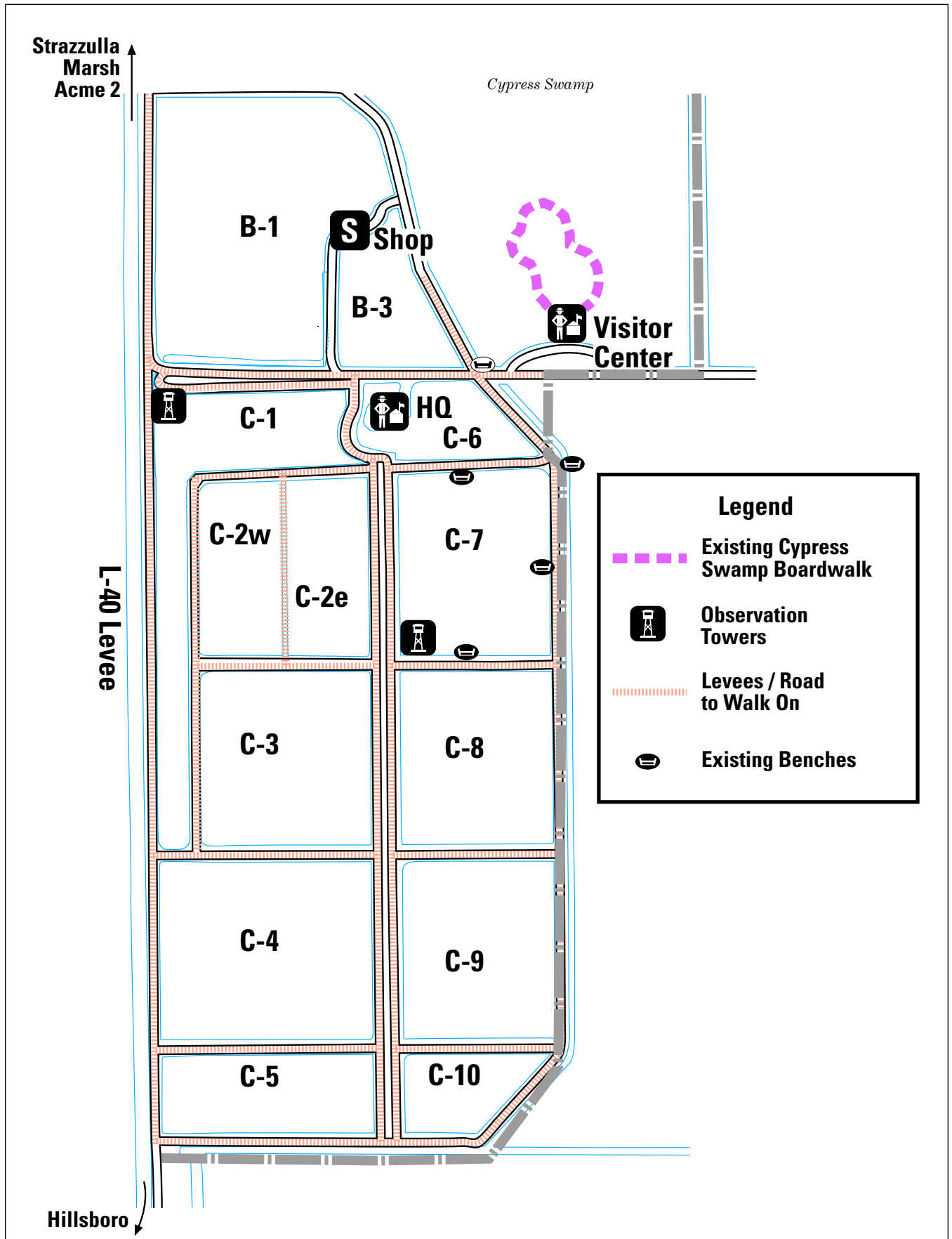


Table 11. Annual cost of staff positions for A.R.M. Loxahatchee National Wildlife Refuge under Alternative 1, "Maintain Current Management"

<i>Management</i>	<i>Grade</i>	<i>Annual Cost*</i>
Project Leader	GS-0485-14	\$104,400
Deputy Project Leader	GS-0485-13	\$88,400
<i>Everglades Program Team</i>		
Hydrologist	GS-1315-13	\$88,400
Wetlands Ecologist	GS-0408-13	\$88,400
<i>Administrative Staff</i>		
Office Assistant	GS-0303-7	\$41,900
Office Clerk	GS-0318-5	\$33,800
<i>Law Enforcement</i>		
Lead Refuge Officer	GS-0025-8/9*	\$52,500
Refuge Ranger	GS-0025-7*	\$46,200
Refuge Ranger (Fees - Lead)	GS-0025-5/6	\$37,700
Refuge Ranger (Fees)	GS-0025-5 T	\$14,800
Fee Collector	GS-0025-3 T	\$ 11,800
Fee Collector	GS-0025-3 T	\$ 11,800
<i>Wildlife/Habitat Management</i>		
Wildlife Biologist	GS-0486-11/12	\$74,300
Wildlife Biologist	GS-0486-9	\$51,200
Biologist (Water Quality & Contaminants)	GS-0486-9	\$51,200
Biological Technician	GS-0486-6/7	\$41,900
<i>Maintenance Operations</i>		
Refuge Operations Specialist	GS-0485-5/7/9	\$51,200
Engineering Equipment Operator	WG-5716-10	\$45,100
Maintenance Mechanic (Facilities)	WG-4749-9	\$42,300
Automotive Worker	WG-5823-8	\$36,900
Maintenance Mechanic Helper	WG-4749-5	\$31,200
<i>Public Use</i>		
Supervisory Interpretive Specialist	GS-0025-9	\$51,200
Refuge Ranger	GS-0025-7	\$41,900
Park Guide	GS-0090-4 T	\$13,200
Subtotal (annual staff costs)		\$1,151,700
Annual fixed costs (phone, gas, diesel, electric, travel, equipment repair, equipment and building maintenance, etc.)		\$120,000
Total Annual Cost		\$1,271,700

* Law enforcement enhanced pay (6c retirement), Salary including benefits (calculated at the highest potential wage possible, including for each position, using FY-2000 wage scales).

T- temporary or seasonal

Figure 23. Proposed boundary expansion near the headquarters of A.R.M. Loxahatchee National Wildlife Refuge

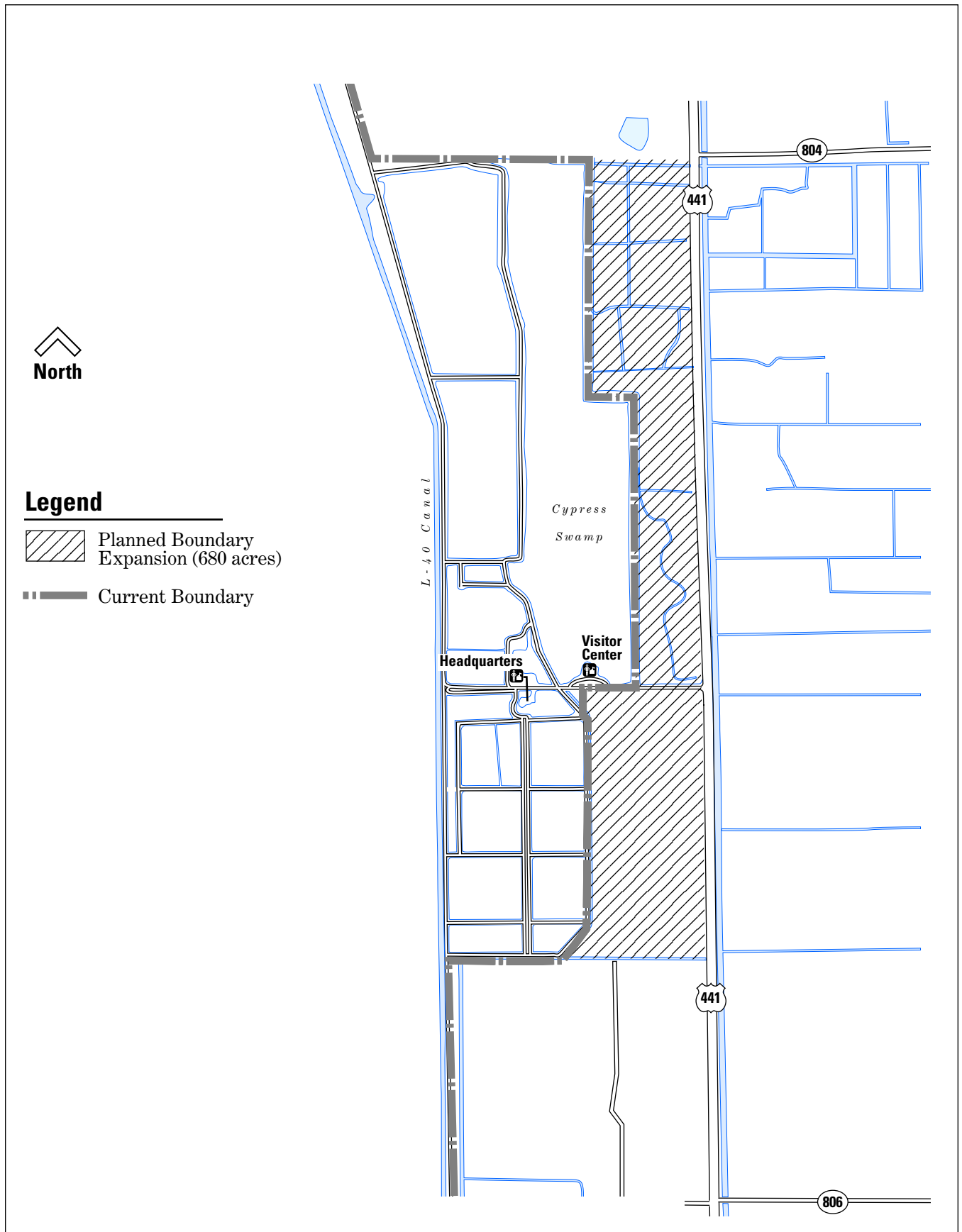


Figure 24. Alternatives 2 and 4: Expanded public use opportunities at the Headquarters Area, A.R.M. Loxahatchee National Wildlife Refuge.

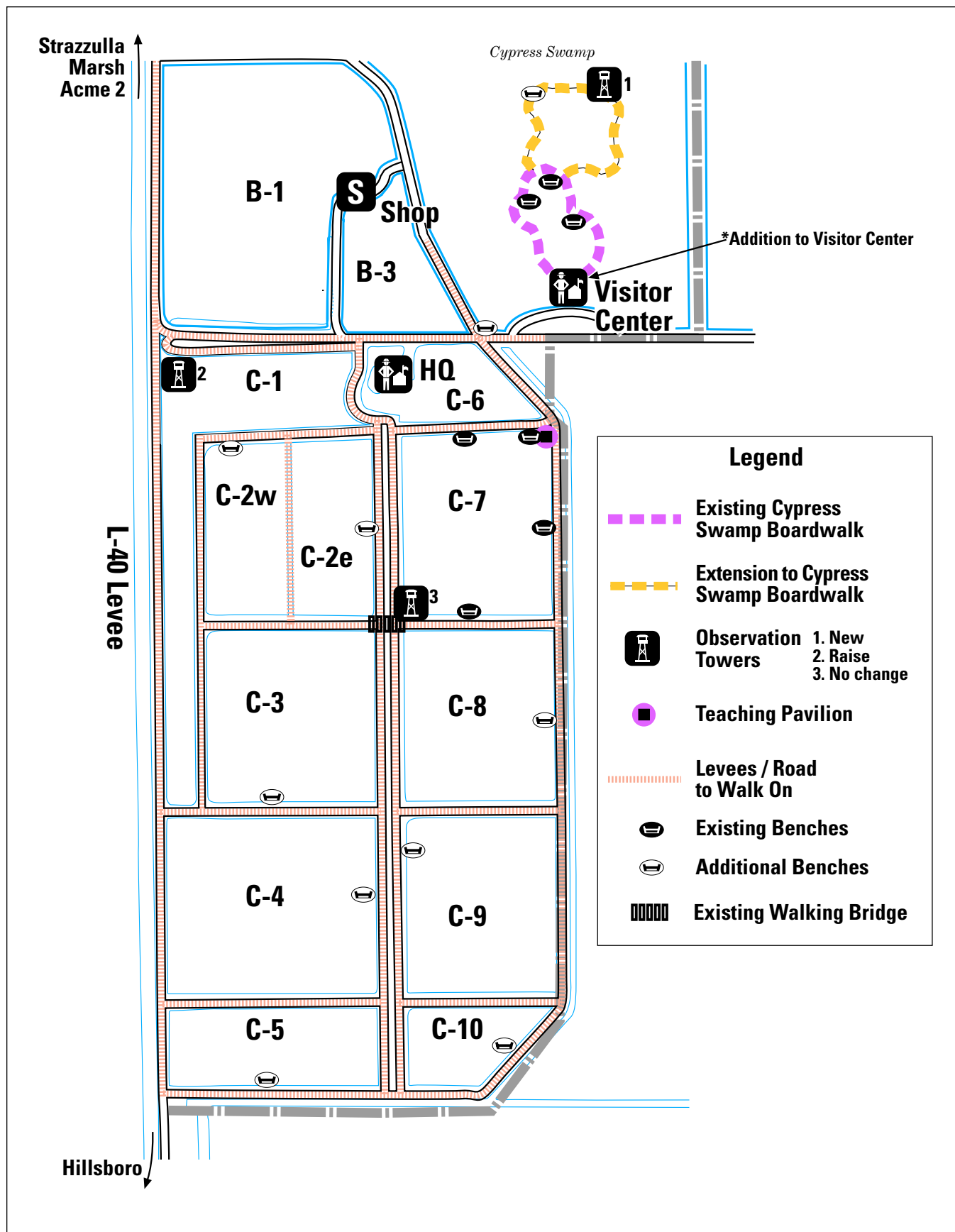


Figure 25. Alternatives 2 and 4: Expanded public use opportunities and waterway zones, A.R.M. Loxahatchee National Wildlife Refuge.

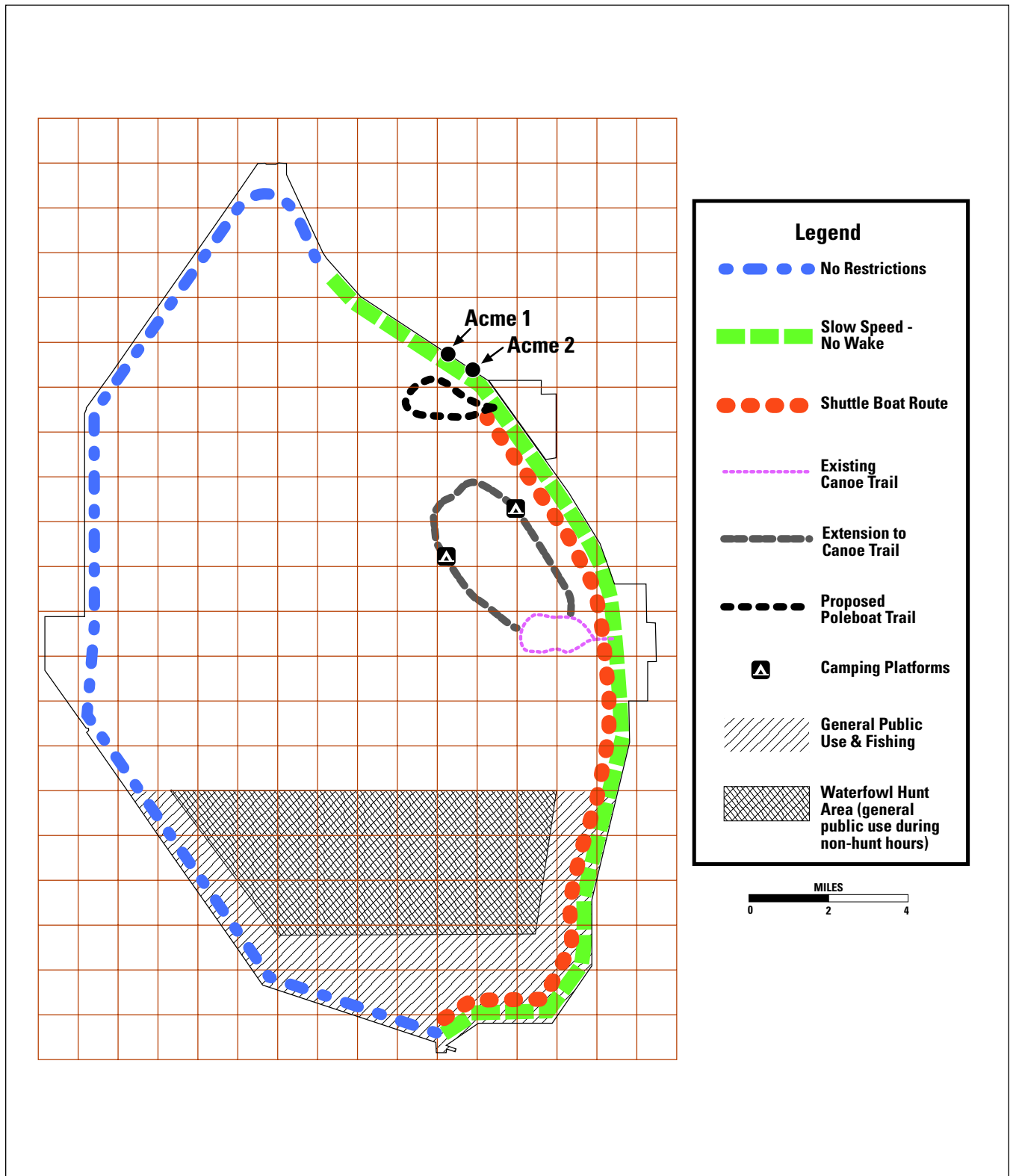


Figure 26. Alternatives 2 and 4: Expanded public use opportunities at Strazzulla Marsh, A.R.M. Loxahatchee National Wildlife Refuge.

